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CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

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Volume 22 New York, April 7, 1920 *Number* 14

Spring Conventions Of Chemical Societies

THE month of April brings the customary spring meetings of the American Electrochemical Society and the American Chemical Society—two of the principal events of the year in chemical circles. The electrochemists, who meet at Boston this week, are provided with an unusually good program, with three symposia —on colloid chemistry, electrically-produced alloys and power for electrochemical purposes. The first of these will be led by the Society's president, W. D. BANCROFT, himself a leading authority on the subject. The second has been contributed by a large number of manufacturers. The third, being the joint product of the Society and the American Institute of Electrical Engineers, will serve an excellent purpose in bringing together the producer and consumer of electric power. It is seldom that the programs of the American Electrochemical Society have excelled that of the Boston meeting.

Less is known at this writing about the general plan or the details of the meeting of the American Chemical Society in St. Louis next week, although we may assume from past experience that it will prove to be a successful meeting. We believe it is unfortunate that the American Chemical Society has never seen fit to follow the customary practice of the electrochemists, mining engineers, and other associations of technical men in publishing papers in advance of the meeting so that those who attend may know what to expect and be prepared with discussion on subjects with which they are familiar. In our judgment the meetings of the American Chemical Society will never hold for its members the attraction and interest which other professional societies secure until there is a change in policy in this respect. Some difficulty may be encountered in adopting this plan, because the inertia of authors must be overcome; but the principal requisite is decision upon the part of the Society's officers. Once this is reached, authors will realize they must conform thereto if they are to find a place on the program. If the change is too drastic to be applied throughout, a beginning could be made by applying it to the larger and better established sections and divisions. It is largely a question of official attitude.

Chemistry and the Interstate Commerce Commission

IN HANDING down a recent decision on the transportation of sodium nitrate the Interstate Commerce Commission made some startling observations on the properties of that well-known substance. After announcing the rates from the seaboard to inland points, the Commission proceeded to dilate upon the chemistry of sodium nitrate and stated that it oxidizes rapidly when exposed to the atmosphere and reacts violently in combination with water. These are indeed shocking details to reveal to chemists who thought they were quite familiar with the characteristics of sodium nitrate.

It may be that this salt is particularly unfortunate in regard to its reputation, for an honorable Senator recently insisted at a committee hearing that Chilean saltpeter is highly explosive and can be ignited by a match.

The facts would not be worth recording merely for the purpose of provoking a smile, but they are significant of the increasing complexity of our daily business life and the necessity for technical knowledge in the transaction of the Government's business. The Interstate Commerce Commission undoubtedly knows much about railroad rates, but is badly in need of a technical adviser when it comes to chemistry.

In Support of the Chemical Warfare Service

WHEN the House of Representatives passed its Army reorganization bill and made the Chemical Warfare Service a separate organization, the outlook for that branch of the service was distinctly improved. It now remains for the Senate to display equally good judgment and assure the country of an Army unit skilled in the means of offensive and defensive gas warfare and able to train the remainder of the troops.

If the Chemical Warfare Service finally becomes established as a separate branch of the Army, it will not be due to the efforts of the Secretary of War or the Chief of Staff, but rather in spite of their opposition. To no one more than to Colonel A. A. FRIES will the retention of the Service be due, if the Senate follows the example of the House. He it was who had charge of chemical warfare on the other side and observed its effects and value. Returning to this country, he first preached the doctrine of the humanity of gas warfare and showed by actual figures the low percentage of death among gas casualties as compared with the results of artillery and infantry fire. His convictions led him to work for the retention of the Service even when its demobilization had been ordered, and his zeal and enthusiasm converted others to his viewpoint. In fact, the revulsion of feeling against gas warfare gradually dissipated to such an extent that no Congressman raised his voice against it when the House bill was passed.

It required no gift of prophecy to foresee the immediate and insistent demand that will arise for chemical warfare if this country again becomes involved in war. That and the air service will be the two new means of offense and defense that will be most urgently needed. Civilian chemists will again be called to the

colors in their professional capacity. In the meantime the least that the Army can do is to retain the skeleton of an organization for the prosecution of research and the training of troops. The latter is in itself a huge problem when it is considered that the National Guard as well as the Regular Army must be trained. Add to this the responsibility of the Chemical Warfare Service for the production of chemical supplies for the entire Army, and we have a task requiring a larger organization than the minimum which has been suggested. The Senate has here an opportunity to urge an increase in the peace-time minimum so that the duties can be performed by Chemical Warfare officers and men, without resorting to special details from other branches of the service which probably would be returned to their original branches in case of hostilities, thus crippling the Chemical Warfare Service when most urgently needed.

An official estimate of the minimum peace-time strength of the Chemical Warfare Service is 171 officers and 2,057 enlisted men, and the Senate will do well to accept the suggestion. It should also see that a clause is introduced defining the duties of the Service, as otherwise a loophole will be left through which opponents of the Service may undermine its independent status and even dismember it on the score that it has no excuse for existence. The duties can well be defined to include the production of gases and smokes for offense, appliances for gas defense, research and investigation in chemical warfare, and the training of the Army in offensive and defensive methods of gas warfare. Until this is done, and the Chemical Warfare Service is firmly established in the Army, the country cannot feel that Army reorganization has been accomplished in the most intelligent and effective manner.

A Balance Nicely Struck

WE ALWAYS object to the charge, sometimes made by narrow-minded scientists, that the engineer is only a craftsman who commercializes science and who sees in a truth only the prospect of monetary gain. On the other hand, we equally regret to hear the "practical" man give vent to unsympathetic criticism of the scientific investigator.

In his address before the American Association of Petroleum Geologists on March 18, GEORGE OTIS SMITH, director of the United States Geological Survey, has struck a splendid balance between the call of pure scientific research and the problems of industry and the arts. He refers to applying the known truths of science for human benefit as "the hallmark of true value"; but he hastens to add the comment: "In a way I suppose we may regard science as an expendible resource; those who apply science to the needs of man seem to require fresh supplies from which to draw for their use. At least it is true that each new advance in the engineering arts calls for a corresponding reinforcement by scientific truth."

It is always a difficult matter to tell when the results of technical investigation will be of value in their application. It is a long step from the test-tube to a satisfactory balance-sheet on a year's plant operations. But the test-tube stage is important, none the less. The executive who plans for an extensive chemical industry (and which of our industries is not in some measure chemical?) without including in his calculations an appropriate allowance for research is likely to find himself left far behind in the industrial race. It is proper that the executive expect this research department to show convincingly that it pays good dividends; but in this department there will always be some problems under study that "we know will never pay," as one director of research put it.

It is fortunate that we have those who love the labors of pure research and who stick to their work despite the charge that they are "impractical acedemic theorists." By their explorations they constantly push back the boundaries of technical ignorance and thus leave more territory for settlement and cultivation by those who follow. Such pioneers perhaps never grow rich; but what pioneer ever does? However, they derive a wonderful store of new experiences which in themselves are a real reward; and they also deserve our cordial support and respect.

There is no ground for contest between the investigator and the one who will apply his discoveries in the useful arts. There is room and need for both. And above all there is need for mutual respect and co-operation.

Conserving Radium As a National Asset

WHEN the Bureau of Mines investigated the radium-bearing ores of Colorado and Utah in 1912 it disclosed a national asset unknown prior to that time, and one that has not been fully appreciated since then. Prior to 1913 the world's production of radium came from Austria, but since then the United States has produced and is producing more of it than all other countries combined. Of the known total world's production of from 100 to 110 grams of radium element it seems likely that domestic ores have yielded 75 to 80 grams, of which say 70 grams has been extracted in this country and the balance abroad.

Early in the development of the radium industry in the West, officials of the Bureau of Mines sounded a warning against the dissipation of our supply of radium, either through non-essential uses in the arts or by unrestricted export to foreign countries. The supply of ore was even then known to be limited, and the life of the mines could be predicted with sufficient accuracy to foresee their exhaustion in a few years. Today the supply of ore seems sufficient to last not more than ten years if the present rate of production and price of radium are maintained.

It seems evident, therefore, that if a conservative note of warning was warranted eight years ago it should now be amplified into a blast of trumpets. Not all of the radium hitherto produced, say 100 grams, is today available for its principal use, viz., the treatment of cancer. Some of it has gone into the production of luminous paint and more of it was consumed during the war in making luminous dials on airplanes, luminous gunsights, etc. All of this is lost to science and medicine. Nor have we in this country in medical use today much more than 20 to 25 grams out of the 70 that our own ores are known to have produced.

If the United States is to accumulate any considerable supply of radium, it would seem high time to make a beginning. Through inquiry we learn that the treatment of cancer with radium is proving more and more successful every day, and that it is practically the only method of treatment in vogue in certain hospitals. But

even here there is danger of scattering the supply too widely, so that sufficient quantities are not available in one place to accomplish the best results. The crux of the matter seems to be that radium is so expensive that private interests cannot afford to purchase it in sufficiently large quantities for its most effective use. The solution of the problem would seem to lie in the private endowment of hospital funds for the purchase of radium or an appropriation by the Government for the same purpose. If the public interest is to be served we must depend on private philanthropy or Government support.

Railroad Efficiency And Steel Requirements

IT IS quite certain that two or three months ago a great many buyers of steel products were misjudging the volume of railroad demand for steel during the remainder of the year. Buyers were highly excited, estimating steel-producing prospects by the light production of the closing months of 1919, and fearing that railroad buying would cut off even a portion of the supplies they had been receiving. The buyers made the steel market, bidding higher and higher prices for steel, and there were evidences of a runaway market. Indeed, a runaway actually began, but it did not continue, rather merging into a condition in which fancy prices obtained for early deliveries, against relatively moderate prices for later deliveries. The result was a high premium market rather than a general runaway.

A clearer perception of the condition and prospects is now being reached, with the result that a more safe and sane market for steel is to be expected. The steel industry is beginning to function well again, the American Iron and Steel Institute's report indicating that steel ingots were produced during February at the rate of 44,200,000 gross tons a year, or 46 per cent better than the average rate during 1912 and 1913, by far the two best tonnage years before the war, and years of approximately equal tonnage. The increase in the rate from January to February was between 8 and 9 per cent, prospects being that March will show a further decided improvement, whereby the quarter's production will represent about 90 per cent of capacity, instead of the 75 per cent mentioned in some of the gloomy forebodings.

Reverting to the fears that the railroads would corral the steel market as soon as the lines were returned to their owners, it is high time that the public, not merely the general run of steel consumers, take a more rational and intelligent view of the work that lies before the railroads. It may be thought natural that when a shipper does not receive enough cars for loading from the railroad, or does not receive raw material because those from whom he buys do not get cars, the shipper should jump to the conclusion that the railroads should buy more cars, and keep on buying until they have enough. But if the shipper has two office boys and both are habitually very late to work he is hardly likely to solve the "problem" by continuing to put additional office boys on his payroll until he finds a good supply every morning at 9 o'clock or whatever his hour may be. He is more likely to look into the habits of the boys he is already paying.

Roughly speaking, there are about 2,500,000 freight cars in the country, a few less than that owned by the railroads, and a few more counting the private cars. The report for last December, by the way, showed 6.2 per cent of the cars "unserviceable," against 5.8 per cent the previous December, just after the Armistice. To add 10 per cent to the number would mean 250,000 cars, costing the better part of a billion dollars. When the roads have functioned well cars have moved, loaded, an average of nineteen miles a day, while when there is "car shortage" the movement is slower. Which would you rather do, spend the major part of a billion dollars or move cars 1.9 miles more per day? A fact that seems pertinent is that there are about 500 freight cars per freight locomotive. This looks hard for the locomotive but seems to give the freight car an easy time. Another noticeable fact is that when there are serious car shortages some of the yards and terminals are badly congested.

Undoubtedly the railroads need more cars, and they are buying some of those additional cars now. They need also to replace old cars, so productive of wrecks, by new cars. Beyond this they need much more motive power, much improvement of terminals and yards, and a great deal of block signaling of track that does not now render the service required of it. Simply to clutter up tracks with more cars will not make the railroads fully serviceable.

The railroad managers are, as a matter of fact, confronted with a very big problem, to put the lines in condition to render much more service and much steadier service. The problem is big financially and big from the engineering side. It is not one that can be solved by instructing the purchasing agent to rush into the market and buy everything at once that is to be had. During the remainder of this year the railroads will make only a beginning. Much more actual work will be done in 1921, and if things go right still more will be done in 1922. Railroad demand will engage relatively little of the steel-making capacity this year, but a great deal more in succeeding years if the railroad companies are able and willing to do their duty to the public.

Artistic Imagination For Engineering Workers

Art is always and everywhere the best way of doing a thing.

THIS definition by one of the *literati* is relevant to the engineering business in that it involves action. Art is concerned not only with museums of junk, philharmonic gatherings or brochures of purple paragraphs, as we are wont to connect it through long association, but applies to the creation or production of anything that is beautiful in its service to the industries and mankind.

An artistic conception of the vocation is essential to the engineer, for, genius or otherwise, he is a worker; and to work successfully he must be led by inspiration, not driven by necessity.

Burning Clay In Sanskrit

WITH the aid of skilled etymologists a committee of the American Ceramic Society has discovered that from the Indo-European base word "car" comes our modern derivation "ceramics." The Greek term "keramos" and Latin "cremo" were intermediate steps. The word means "to burn" earthy materials. The engineer may now add to polite conversation on the arts when the subject of Ming dynasty pottery is broached in the drawing room.

British Chemical Industry

(FROM OUR LONDON CORRESPONDENT)

London, March 8, 1920.

INTEREST in the United Kingdom has centered upon the continued appearance of new capital issues and the adjustments and changes in policy which are occasioned by them. As was to be expected in view of the acquisition of the Castner-Kellner interests, Brunner Mond & Co. are now to purchase the business of Electro Bleach & By-Products, Ltd., of Middlewich, the latter firm being the only serious competitor in regard to electrolytic caustic soda. In addition it is rumored that as a logical consequence of Brunner-Mond's purchase of the government Haber plant at Billingham, it is intended to consolidate the firm's position in the nitrogen industry as far as possible. The dispute between Brunner-Mond and Lever Bros. in regard to the hydrogenation of fats and the manufacture of alkali was settled some time ago, and the transfer to Lever Bros. of Crosfield & Gossage's soap works is evidently intended to leave the soap industry in the hands of the one combination and the alkali industry in that of the other, probably with a mutual understanding in regard to the use of processes germane to both industries.

The alkali position will probably be affected in the future by the large quantities of sodium carbonate which will be available in British East Africa from the Magadi Soda Co. Operations on the branch railway to the deposits were suspended during the war, all such facilities being required for military operations. The railway has now been restored to the company, and it is stated that the first shipments of soda will be forthcoming in the summer of this year.

BRITISH CELLULOSE CO.

The British Cellulose Co., it will be remembered, erected large works at Spondon, near Derby, to manufacture cellulose acetate for airplane manufacture. The British Government provided about $9,000,000, secured upon the property, and after many vicissitudes, production commenced on a large scale some months before the end of the war. The company was adversely criticized, but largely exonerated by the special committee appointed to investigate its activities. Further capital being now required, the government was induced to exchange its debentures for profit-sharing preference shares, being part of the new issue. We thus have the curious situation of the government becoming a speculative shareholder in a chemical manufacturing company whose objects, as explained in the prospectus, go far beyond that of dope manufacture. One of the probable sources of profit indicated is that of artificial silk manufacture, and it is not surprising that much objection should have been taken to the government's course, not only by the artificial silk manufacturers, but also by the general public, which does not appreciate government competition with private enterprise.

BRITISH MANUFACTURERS' REPORT

The report of the Association of British Chemical Manufacturers previously referred to[1] has been issued in abstract to the press, but it is still not available in full to the general public or to chemical manufacturers abroad, although it is hardly possible to prevent its indirect transmission. Missions such as that which issued the above report seem to give rise to some misunderstanding and suspicion. Thus, in the above case, a creditable report was evolved in the short space of three weeks' stay in Germany, yet adverse criticisms in regard to its contents have been made by those who did not take part and it has even been hinted that much additional useful information might have been included, which was either overlooked or withheld on account of uncertainty or self-interest. Again, in the case of the Color Users' Purchasing Commission, which visited Germany at the end of January, the principle of collective buying which its name indicates is not generally accepted (by the smaller users, at any rate) as the most advantageous one, and this in spite of the obvious lessons that could be drawn from such methods of co-operation in Germany before the war.

THE SPIRIT OF CO-OPERATION

These internal dissensions are almost entirely due to the lack of co-operation in the British chemical industry as a whole and the ingrained distrust, jealousy and suspicions of the smaller manufacturers and, in some degree, of the various learned societies, which time and experience alone can eradicate. The fine chemical industry is a distinct sinner in this respect, and the leading firms in that industry show no signs of taking a lead in regard to co-operation, but maintain complete silence as to their future program. Signs are, however, not wanting that the smaller fine chemical manufacturers are discontented with the lack of capital of the industry as a whole and the aloofness of the larger manufacturers.

An attempt will probably be made to prevent the closing down of some of the smaller works, which will be inevitable if the industry as a whole is not placed on a secure foundation comparable with the American and continental organizations. As regards the various technical societies, it is understood that the scheme by which they will nearly all be accommodated in a central building on the lines of the Engineering Societies in the United States will shortly be formulated and that it will involve the raising of a very large fund. The matter is in the hands of the Federal Council of Learned and Scientific Societies under the guidance of Sir William Pope.

A more favorable moment could hardly have been chosen than the present in appealing for funds, when the value of science and chemistry in particular is at last being appreciated in some measure by the general public. The dinner of the Chemical Trade Association did not justify the hopes of its organizers, but when the older and more influential manufacturers proceed with their new and more comprehensive association, the position will become more stable. The functions and uses of a chemical merchant are not properly appreciated either by the general public or by the manufacturers, and in fact, the latter have lately been making strenuous efforts by direct and indirect propaganda to eliminate the merchant and middleman as far as possible. In doing so and in setting up their own special sales organizations, they overlook the fact that a merchant can dispose of the output of several factories more easily and at a lower cost than a single manufacturer can deal with his own output. While this policy may be satisfactory for the largest firms or for co-operative sales organizations in special lines such as sulphate of ammonia, the policy is unsound and may lead to retaliation from the merchants should they themselves decide to manufacture.

[1] See CHEM. & MET. ENG., vol. 22, No. 9, March 3, 1920, p. 389.

Ethylene and Propylene Chlorhydrins and Glycols From Oil Gas

Description of the Synthesis of Glycols From Ethylene and Propylene by Clorhydrating and Hydrolyzing—Content of Ethylene and Propylene in Oil Gas — Details Regarding Methods, Distilling and Hydrolyzing

By BENJAMIN T. BROOKS

THE chemical utilization of petroleum, that is, in ways other than direct combustion as fuel, readily suggests a series of latent or undeveloped possibilities. The present work is an effort to develop one phase of this problem.

Interest in the simpler chlorhydrins and glycols has been recently revived in connection with the substitution of glycols for glycerine in explosives and also in connection with the manufacture of ββ dichlorethyl sulphide, or the now well-known mustard gas. The Germans made their mustard gas from ethylene chlorhydrin, but in the Allied countries this method was superseded by the direct or sulphur chloride method.[1]

The simpler glycols have frequently been proposed as substitutes for glycerine but until quite recently a satisfactory method for their commercial manufacture has been lacking. In normal times the supply of glycerine available in the sweet lye from soap manufacture more than meets the demand for such material and the larger soap manufacturers are able to recover glycerine of good quality at a very low cost. However, it is possible that uses for the glycols may be found in which the glycols may possess certain advantages over glycerine. Ethylene and propylene glycols are much less viscous than glycerine and may therefore have a certain advantage over the latter in refrigeration systems, low freezing solutions and the like.

Several years ago A. M. Hough[2] showed that glycols can be smoothly nitrated to the corresponding dinitrates and that these glycol dinitrates may be mixed with nitroglycerine to form very low freezing mixtures. Hough seems to have been the pioneer of practical work in this field, although the glycol nitrates were made and described many years ago by Henry,[4] Champion,[4] Demjanow,[5] Nef[6] and others. Mathews, Strange and Bliss[7] have patented explosives containing nitrated 1,2 glycols compounded with nitrocellulose, infusorial earth, etc., and under the Jolicard patent[8] explosives containing nitroglycerine, together with nitrocellulose, nitroglycerine and nitrate salts, are said to have been manufactured industrially in Europe.

Other substances capable of lowering the freezing point of nitroglycerine and possessing explosive values of their own have been tried, for example glyceryl monochlorhydrin dinitrate[9] and glyceryl methyl ether dinitrate.[10] One objection which explosive manufacturers have repeatedly raised against the nitroglycols is their high volatility as compared with nitroglycerine, and their toxicity. Several patents on explosives containing nitroglycols have recently been granted to J. Barab.[11]

Ethylene and propylene glycols, as described in the earlier literature, are very hygroscopic liquids, considerably more volatile than glycerine. This tendency to evaporate causes flexible glue compositions containing glycol to become brittle. On the other hand, when added to tobacco, the natural resins present appear to retard the evaporation of the glycol.

Trimethylene glycol, or 1.3 dihydroxypropane, has also long been known and is obtained in commercial quantities as a minor byproduct in the manufacture of glycerine and is apparently formed from glycerine itself by fermentation. The total available supply of this material is, however, quite small.

The cheapness of chlorine under present conditions brings the manufacture of these glycols and chlorhydrins within the bounds of economic production. The following résumé indicates the methods thus far found successful and indicates also other possible methods.

Dihalides

In the older published work the dibromides were employed almost exclusively, on account of the ease of preparing them in the laboratory and the facility with which they are hydrolyzed or converted into esters. The chlorination of oil gas with the formation of Dutch liquid was first carried out by Faraday in 1825.[12] As pointed out by Armstrong and Miller,[13] "oil gas" has the same general composition, whether made from fatty or mineral oils. But the chlorination of ethylene to the dichloride, which is the kernel of the matter, was first carried out in 1795 by the four Dutch chemists from whom the dichloride gets its name of "Dutch liquid." Several recent patents on the subject refer to special methods of chlorination.[14]

[1] The preparation of mustard gas, or ββ dichlorethyl sulphide, from ethylene chlorhydrin was plainly indicated by the work of Victor Meyer and Clark, and involves treatment of aqueous ethylene chlorhydrin with sodium sulphide, concentrating or dehydrating the dioxysulphide thus formed and warming the latter with concentrated hydrochloric acid. It was perhaps fortunate that the manufacture of ethylene chlorhydrin, on a commercial scale, had not been perfected in any of the Allied countries, since by the development of the direct sulphur chloride process the Allies were able to reach a production capacity for mustard gas approximately thirty times that of the Central Empires. (Pope, *J. Chem. Soc.*, vol. 115, p. 402, 1919.)

[2] U. S. Pat. 1,206,233.

[3] *Ann. d. Chim.* (4), vol. 27, p. 253 (1872), vol. 28, p. 425 (1873).

[4] *Compt. rend.* vol. 73, p. 571 (1871).

[5] *Chem. Zentr.*, 1899, vol. 1, p. 1,064.

[6] *Liebig's Ann.*, vol. 335, p. 279 (1904); cf. also Mixter, *Am. Chem. J.*, vol. 13, p. 507 (1891); Carlson, *Ber.*, vol. 40, p. 4,192 (1907).

[7] Fr. Pat. 458,309 (1913).

[8] Fr. Pat. 456,456 (1912). One composition reported is as follows: nitroglycerine 66.4 per cent, glycol dinitrate 16.6 per cent, collodion 5.0 per cent, KNO_3 10.0 per cent, cellulose 2.0 per cent Cf. *Z. Schiess u. Spr.*, 1913, p. 234.

[9] Sprengstoffwerke R. Nahnsen & Co., D. R. Pat. 37,853.

[10] Jones, *J. Chem. Soc.*, vol. 115, p. 76 (1919).

[11] U. S. Pats. 1,307,032, 1,307,033, 1,307,034.

[12] *Philos. Trans.*, 1825, p. 440.

[13] *J. Chem. Soc.*, 1886, p. 74.

[14] Brooks & Smith, U. S. Pats. 1,231,123, 1,235,283; Smyth, *J. Soc. Chem. Ind.*, vol. 35, p. 1,130 (1916); Tinker, Br. Pat. 108,602; Mercereau, U. S. Pat. 1,224,485; Harding, Br. Pat. 126,511 (1918).

The author, with I. W. Humphrey,[15] has shown that the conversion of ethylene chloride to glycol proceeds readily when heated under pressure with methyl alcohol and an alkali formate, ethylene diformate being formed as an intermediate product. Aqueous carbonate or bicarbonate solutions at somewhat higher temperatures and pressures also give good yields, which process has been patented by Matter.[16]

Chlorhydrins

The conversion of ethylene and propylene chlorhydrins to the corresponding glycols may be effected by heating with aqueous bicarbonate or carbonate solutions. The best yields, about 85 per cent of the theory, are obtained by heating chlorhydrin solutions containing not over 20 per cent chlorhydrin with a slight excess of sodium bicarbonate in an autoclave to 110 deg. for about two hours. Hydrolysis of the chlorhydrin with evolution of carbon dioxide is quite appreciable at 70 deg. but by simply refluxing the chlorhydrin with bicarbonate solution the yield of glycol is about 50 per cent of the theory. This method, which has also been patented,[17] gives very much better yields than the older methods described in the literature by Henry and others. Typical results of this method are described below.

Oxidation of olefines to glycols by cold dilute permanganate solution is frequently given in text books as a general method, but as the yields are seldom more than 5 per cent of the theory and the materials costly, this is clearly out of the question as a commercial method. However, catalytic oxidation by oxygen or air through an intermediate oxygen carrier, as is suggested by the work of Hofmann and Schneider[18] on oxidation in the presence of a very small quantity of osmic acid, would be economically sound should suitable catalysts be discovered.

Raw Materials

Oil gas, containing 35 to 45 per cent olefines, still gases from petroleum cracking stills and containing 10 to 12 per cent olefines, and ethylene made by the decomposition of alcohol are the only sources of ethylene and propylene of practical importance. The hydrogenation of acetylene to ethylene has never been carried out on a large scale, nor by any method having great promise of industrial success. One possible source of these simpler olefines is suggested by the large quantities of ethane and propane which are available in natural gas, or more specifically, in the very light fractions ordinarily permitted to escape from casing head gasoline which has been condensed under considerable pressure.

Ethane and propane are partially converted into ethylene and propylene by heat and the monochlorides are almost quantitatively decomposed to the corresponding olefines by passing the vaporized chlorides over pumice impregnated with barium chloride and heated to 400 to 450 deg. C.[19]

The manufacture of very pure ethylene by the catalytic decomposition of alcohol, together with a little steam, in contact with kaolin at 400 to 500 deg. has been carried out on a large scale with excellent yields and low cost by the U. S. Chemical Warfare Service.[20]

Although oil gas has been manufactured for a great many years and under widely varying conditions, little or no attention has been given to its composition with respect to the different olefines which it contains, as these are commonly determined together as "illuminants."

The data given in Table I indicate approximately the composition of oil gas, with respect to ethylene and propylene, as made in commercial practice in a gasifying apparatus of the Pintsch type. The temperatures given are those at the beginning and end of the gas-making periods. From the work of Whitaker, Rittman and Alexander, it is certain that the percentages noted are not the equilibrium values for these temperatures. Also from the work of Hall it is recognized that comparatively slight variations in temperature produce large changes in the composition of the resulting gas. The data given are merely those obtained from gas made by commercial practice.

TABLE I. PER CENT ETHYLENE AND PROPYLENE IN OIL GAS[21]

Temp. Deg. C.	Higher Olefines, Per Cent	C_2H_4 Per Cent	C_3H_6 Per Cent	Total Olefines Per Cent
805—650	1.4	18.6	16.3	36.3
660—535	1.6	19.0	18.3	38.9
635—535	2.4	22.4	12.5	37.3
625—535	2.6	22.6	13.7	38.5
615—425	3.8	25.7	12.0	41.5

The data in Table II show the composition of the oil gas obtained by rapidly passing the oil vapors, under pressure, through tubes heated to certain definite temperatures in an apparatus of the Hall type.

TABLE II. COMPOSITION OF OIL GAS MADE IN TUBES MAINTAINED AT DEFINITE TEMPERATURES

Temperature, deg. C.	600	650	700	730
Pressure, lb.	57	72	83	95
Ethylene, per cent	19.3	19.0	17.7	17.5
Propylene, per cent	28.0	28.4	23.9	20.0
Higher olefines, per cent	3.2	4.2	3.5	3.1
Total olefines, per cent	50.5	51.6	45.1	40.6

Although the per cent of total olefines is somewhat less at the higher temperature, the net yield is considerably greater on account of the larger volume of gas produced, as is indicated by the figures given in Table III.

TABLE III. PER CENT OIL GASIFIED IN HALL TYPE APPARATUS AT DIFFERENT TEMPERATURES

Temperature, Deg. C.	Per Cent Gas	Per Cent Ethylene and Propylene
605	17.7	47.9
625	26.6	46.1
645	37.6	44.9
665	40.0	43.7
685	40.8 (?)	42.6
705	48.7	39.5
725	66.6	38.5

It will be noted in the analysis quoted that the higher olefines commonly represent about 4 per cent by volume of ordinary oil gas and may be present to the extent of 10 per cent in a gas made at low cracking temperature and containing about 52 per cent total olefines. In order to limit the chlorhydrins and glycols to ethylene and propylene (incidentally removing[22] also benzine and

[15] *J. Ind. Eng. Chem.*, vol. 9, p. 750 (1917).

[16] U. S. Pat. 1,237,076.

[17] Soc. An. d'Explosifs et de Prod. Chim., Fr. Pat. 458,733 (1912).

[18] *Ber.*, vol. 46, p. 1,657 (1913); vol. 48, p. 1,585 (1915).

[19] This has not been carried out on a large scale.

[20] Dorsey, *J. Ind. Eng. Chem.*, vol. 11, p. 288 (1919); Engelder, *J. Phys. Chem.*, vol. 21, p. 676 (1917); Hough, U. S. Pat. 1,206,222, employs $Al_2(SO_4)_3$ on an inert material at 350-400 deg. Cf. also Norris, *J. Ind. Eng. Chem.*, vol. 11, p. 821 (1919).

[21] The above values were obtained by absorbing the higher olefines in 70 per cent sulphuric acid (Hempel pipette), the propylene in concentrated sulphuric acid sp.gr. 1.84 at room temperature, and the ethylene in bromine water. According to Nef (*Liebig's Ann.*, vol. 318, p. 1901) these olefines may be quantitatively separated and determined in this manner. In the author's opinion, this method is much more accurate than that of fractionating the mixture of olefine dibromides, and is very much more rapid.

[22] The resulting liquid is practically identical with the light "dripa" which it is customary to separate in the manufacture of Pintsch gas.

gasoline vapors), it is necessary to remove the higher olefines, which in this work was done by cooling and compressing to 175 to 200 lb. pressure.

Ethylene and Propylene Chlorhydrins

The problem of manufacturing these chlorhydrins proved not to be particularly difficult, once the discovery was made that the addition of hypochlorous acid to ethylene and propylene takes place at ordinary temperatures in very dilute aqueous solution with extreme rapidity.

Some of the older work, for example that of Wurtz and Carius, was misleading in this respect. They permitted ethylene to be slowly absorbed by a fairly strong solution of hypochlorous acid during long standing in the dark at room temperature and atmospheric pressure. The chief factor retarding the actual preparation of the chlorhydrins appears to be the solution of the gas in the aqueous solution. Thus we have found that it is not necessary to employ solutions more concentrated than 0.10 per cent total hypochlorites. Conditions which promote the solution of the gas in the aqueous solution, as for example agitation or moderate pressures, and which should not appreciably affect the rate of the reaction with HOCl, very greatly accelerate the formation of chlorhydrin.

The Preparation of Hypochlorous Acid

In the earlier work on chlorhydrins the method of preparing hypochlorous acid usually was the well-known reaction between mercuric oxide and chlorine water.[23] The method of adding a weak acid, such as boric acid, to a hypochlorite in dilute aqueous solution was carried out by Lauch,[24] Bamberger,[25] Baeyer and others. A more satisfactory method is that of Wohl and Schweitzer,[26] which consists in passing chlorine into a cooled solution of sodium carbonate or bicarbonate. Weyl also recommends this method.[27] H. V. Walker has patented a variation of this method, which consists in adding an excess of sodium bicarbonate to an alkaline solution of sodium hypochlorite.[28]

Although quite concentrated solutions of sodium hypochlorite are quite stable when sodium hydroxide is in excess, as shown by Muspratt and Smith,[29] the decomposition of such concentrated hypochlorite solutions is so rapid the instant free hypochlorous acid is present that good yields of chlorhydrin are not obtainable from them. The gradual liberation of free HOCl, in the presence of ethylene and propylene, by weak acids such as CO_2 and boric acid, were tried but the yields of chlorhydrin based on the original quantity of hypochlorite were only 25 to 30 per cent of the theory. Somewhat better results were obtained by liberating HOCl from bleaching powder by CO_2 in the presence of ethylene and according to Norris[30] the Germans made ethylene chlorhydrin, for mustard gas manufacture, in this manner.

The continuous process described below gave much better results, however, and work with concentrated hypochlorite solutions was abandoned.

McElroy[31] has patented a novel and ingenious method of manufacturing chlorhydrins from ethylene or oil gas, which consists in passing the olefines into a mixture of steam and chlorine. According to the author's experience, on a large experimental scale, large proportions of highly chlorinated oily products result under these conditions. The apparatus required is large and comparatively costly. Typical results are as given in Table IV.

TABLE IV. TREATMENT OF OIL GAS WITH STEAM AND CHLORINE

	I	II	III
Total gas used, cu.ft.	1,920.00	1,730.00	2,010.00
Gas rate, cu.ft. per hr.	240.00	216.00	251.00
Total chlorine, lb.	53.40	51.60	52.20
Pounds chlorine to 1 lb. chlorhydrin.	2.27	2.40	1.86
Dilute chlorhydrin distillate, lb.	582.00	312.00	545.00
Steam, total lb.	1,460.00	1,364.00	1,477.00
Per cent chlorhydrin in distillate.	4.05	6.91	5.15
Steam, lb. to 1 lb. chlorhydrin.	62.00	63.00	52.80
Total lb. chlorhydrin.	23.50	21.50	28.00

From what is known of the properties of hypochlorous acid it seemed probable that better yields would be obtained by working with cold aqueous solutions. Considerable careful work on the system

$$Cl_2 + H_2O \rightleftharpoons HOCl + HCl$$

has shown that the relative amount of hypochlorous acid which is present at any one moment is quite small. But, as shown by Gomberg,[32] the velocity of the combination of HOCl and ethylene is so much greater than that of the formation of ethylene chloride that very excellent yields of ethylene chlorhydrin may be obtained by passing chlorine and ethylene into cold water, with vigorous agitation to promote the solution of the two gases.

This operation is readily carried out with oil gas in a suitable apparatus, i.e., one in which the cold reaction solution does not have to be pumped or circulated. The apparatus developed by the author for making chlorhydrin was of the liquid circulating type, and in order to minimize the corrosion difficulties the free HCl in the solution was neutralized by soda ash, sodium bicarbonate or borax, although, as shown by Gomberg, the salt which thus accumulates in the solution retards the production of chlorhydrin. The general plan of the apparatus employed is shown in Fig. 1. In a small apparatus of this type, in which the reaction tower measured 12 ft. x 12 in., it was shown that the production of chlorhydrin was fairly rapid until the solution contained about 5.0 per cent chlorhydrins. Thus in one experi-

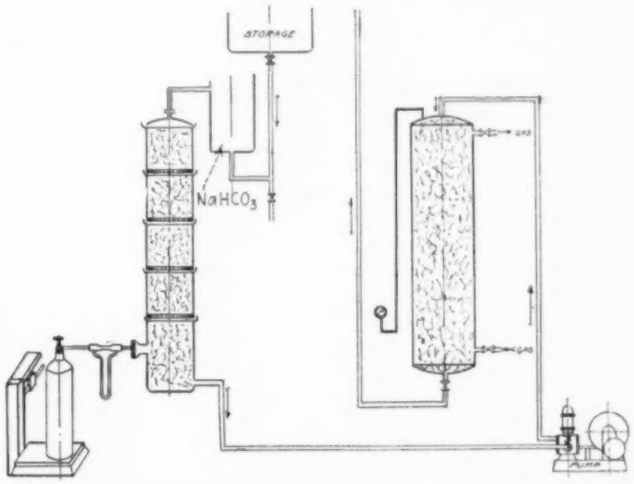


FIG. 1. SKETCH SHOWING MANNER OF TREATING OIL GAS WITH HYPOCHLOROUS ACID SOLUTION

[23] Reformatsky, *J. prakt. Chem.*, N. F., vol. 40, p. 396 (1889).
[24] *Ber.*, vol. 18, p. 2,287 (1885).
[25] *Liebig's Ann.*, vol. 288, p. 81 (1895).
[26] *Ber.*, vol. 40, p. 94 (1907).
[27] "Die Methoden d. Org. Chem." Leipsig, 1911, vol. 2, p. 794.
[28] U. S. Pats. 972,952, 972,954.
[29] *J. Soc. Chem. Ind.*, vol. 17, p. 1,096 (1898); vol. 18, pp. 210,-232 (1899).
[30] *J. Ind. Eng. Chem.* vol. 11, p. 817 (1919).
[31] U. S. Pats. 1,253,616; 1,295,339.
[32] *J. Am. Chem. Soc.*, vol. 41, p. 1,414 (1919).

ment lasting 14 hr. the concentration of chlorhydrin in the solution at the end of 7.5 hr. was 5.0 per cent, but in the next 6.5 hr. only increased to 6.65 per cent, although chlorine and oil gas were supplied at the same rate and all other conditions, pressure and temperature, remained the same. Also it was noted that propylene reacted more readily than ethylene, as was indicated by the fact that the proportion of ethylene to propylene was much greater in the exit gases than in the gas supplied to the hypochlorous acid solution; for example, a gas containing 15.7 per cent ethylene and 10.2 per cent propylene after passing through the apparatus showed 3.4 per cent propylene and 3.6 per cent ethylene.

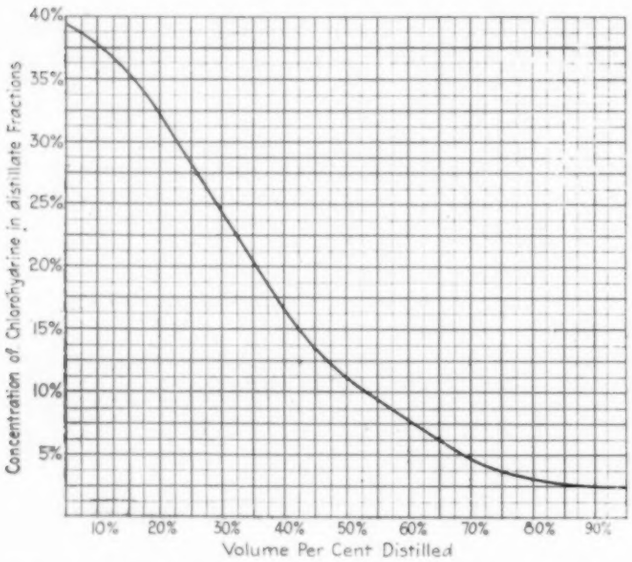


FIG. 2. DISTILLATION BEHAVIOR OF ETHYLENE CHLORHYDRIN ABOUT 24 PER CENT BY WEIGHT SOLUTION

After a large number of experimental runs, the data of which it is not necessary to include here, a larger cement lined apparatus was erected, of dimensions permitting the employment of about 600 lb. of chlorine and 1,000 gal. of solution per batch. The circulating solution was cooled to keep the temperature practically constant at 15 deg. C. The following results, obtained in the larger apparatus, under 75-lb. gas pressure and using oil gas containing 34 to 36 per cent total ethylene and propylene, are representative:

TABLE V. ETHYLENE AND PROPYLENE CHLORHYDRINS FROM OIL GAS AND COLD AQUEOUS HOCl

Exp. No.	Chlorine, Lb.	Gas, Cu.Ft.	Sodium Bicarbonate, Lb.	Olefines Used, per 100 Cu.Ft. Gas	Chlorhydrin Per Cent	Chlorhydrin Lb.
I	415	3,470	607	32.6	4.55	407
II	424	4,290	600	28.8	4.70	425
III	531	5,060	650	29.4	5.30	488
IV	540	4,530	700	26.5	4.65	430
V	681	6,040	750	28.4	7.75	561

Sodium bicarbonate may be replaced by soda ash with equally good results, but the solution must be cooled more strongly to maintain the temperature at 15 deg. on account of the heat of solution of soda ash and the larger amount of heat developed by neutralization.

Aqueous ethylene chlorhydrin is not affected by free chlorine at 0 deg. Propylene chlorhydrin is only very slowly acted upon by free chlorine at this temperature. At about 95 to 100 deg. and in the presence of steam small quantities of very acrid irritating substances are produced, probably chloracetaldehyde and chloracetone.[33] Gomberg[34] has noted the distillation behavior of dilute ethylene chlorhydrin solutions. Fig. 2 indicates the distillation behavior of an ethylene chlorhydrin solution, 24 per cent by weight, the first fractions consisting of the constant boiling mixture containing 37.5 per cent chlorhydrin. Fig. 3 gives the distillation behavior of the oil gas chlorhydrins, ethylene and propylene chlorhydrins being present in about equal amount, the aqueous solution taken for distillation containing 24 per cent by weight of the chlorhydrins. The same figure also shows (curve I) the effect of saturating a solution of the same concentration with common salt. On saturating with salt two layers are formed, the upper layer containing most of the chlorhydrin, and it will be noted that the distillation of the saline chlorhydrin solution more nearly approaches that of a pair of two mutually insoluble liquids. When the initial solution contains more chlorhydrin than corresponds to the constant boiling mixture, the latter will of course distill first and finally anhydrous chlorhydrin will distill, as indicated in Fig. 4.

As the work described in the present paper was carried out under industrial conditions and primarily for the purpose of making the mixed glycols, no attempt was made to distinguish between the two isomeric propylene chlorhydrins. Michael,[35] Henry,[36] Smith[37] and others have shown that on the addition of HOCl to propylene the resulting chlorhydrin mixture contains mostly chlor-β-hydroxypropane.

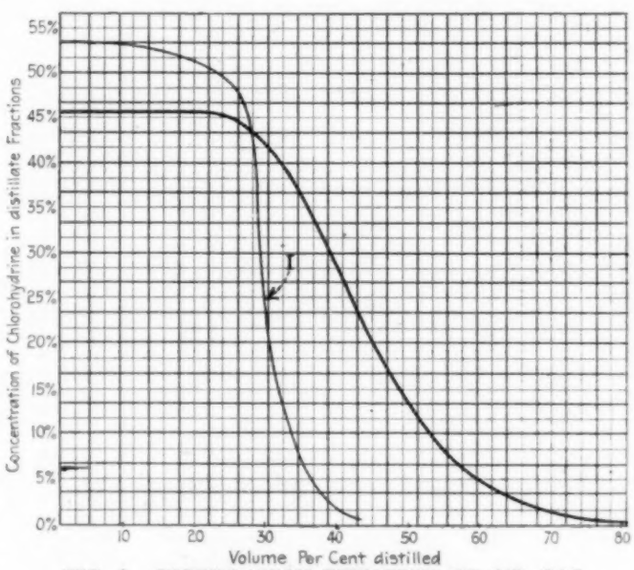


FIG. 3. DISTILLATION BEHAVIOR OF OIL GAS CHLORHYDRINS

That anhydrous chlorhydrins possess valuable solvent properties is well known, but the ease with which they hydrolyze, with the formation of hydrochloric acid, greatly restricts their field of usefulness. The hydrolysis of an 8 per cent solution of ethylene chlorhydrin at 95

[33] The relative stability of ethylene chlorhydrin to chlorine is of interest as indicating the influence on the $-CH_2OH$ group of a chlorine atom attached to the adjacent carbon atom. It tends to confirm also the generally accepted view that when ethyl alcohol is chlorinated the $-CH_2OH$ group is first attacked to form CH_3CHO, which then immediately is chlorinated in the methyl group, finally to chloral.

[34] *J. Am. Chem. Soc.*, vol. 41, p. 1,414 (1919).

[35] *Ber.*, vol. 39, p. 2,785 (1906).

[36] *Bull.*, Acad, royal Belgique 1906, p. 523: *Comp. rend.*, vol. 134, p. 1,070 (1902).

[37] *J. Chem. Soc. Abs.* (1913), p. 35; cf. Krassusky Jahresber. d. Chem. (1901), p. 581.

deg. (maintained at 95 deg. in a Freas oven) is graphically indicated in Fig. 5. The hydrolysis of propylene chlorhydrin, 9.4 per cent, or equivalent to the concentration of the ethylene chlorhydrin solution, is also shown in Fig. 5.

The use of chlorhydrins as solvents for cellulose acetate has been patented by Lindsay and by the von Hayden Chemical Co.[38] Glycol mono-acetate is said to affect favorably the physical properties of cellulose acetate films and also increases the ability to dye.[39]

Although the simpler chlorhydrins have frequently been salted out with potassium carbonate, it was apparently not observed until comparatively recently that by merely warming the aqueous solutions with alkali carbonates or bicarbonates, glycols are produced. Evans[40] stated that the alkali carbonates converted these chlorhydrins into the corresponding alkylene oxides, but did not actually isolate or identify them. On heating aqueous solutions of ethylene or propylene chlorhydrins and sodium bicarbonate to 65 deg., marked evolution of carbon dioxide takes place. By refluxing with sodium carbonate or bicarbonate and carefully working up the aqueous solution for glycol, yields of 44 to 48 per cent of the theoretical are obtained. The remainder is converted into ethylene and propylene oxides which pass off with the carbon dioxide. The older statements are therefore partly correct. By carrying out the reaction in an autoclave and heating to 105 to 110 deg. C. for 2 hr., yields of glycol equivalent to about 90 per cent of the theory are obtained. The remainder is a tarry material which cannot be distilled at 10 mm. without decomposition and is probably identical with the non-distillable

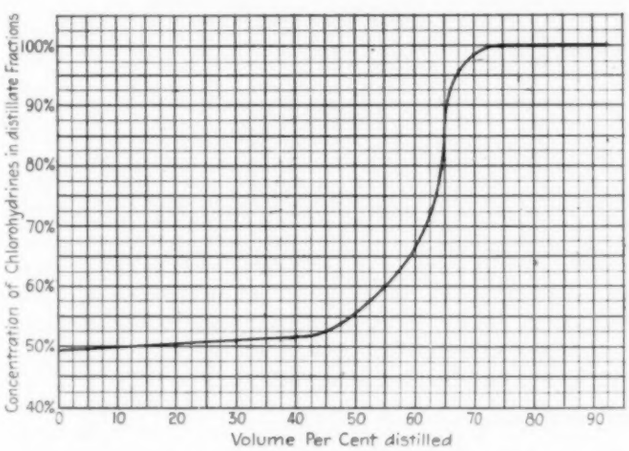


FIG. 4. DISTILLATION BEHAVIOR OF 70 PER CENT ETHYLENE AND PROPYLENE CHLORHYDRIN MIXTURE: 30 PER CENT WATER

amorphous substance obtained by Wurtz by treating ethylene oxide in aqueous solution with alkali.[41]

It might conveniently be noted here that the yields of alkylene oxides obtainable from the simpler chlorhydrins depend upon the concentration of caustic alkali and the removal of the volatile oxides from the reaction mixture as rapidly as possible. Thus by dropping concentrated, nearly anhydrous (90 per cent) ethylene chlorhydrin upon solid caustic soda and stirring slowly to break up the crusts of sodium chloride, a yield of 80 per cent of the theory of ethylene chlorhydrin is obtained. When an equivalent quantity of 10 per cent caustic soda is employed no ethylene oxide can be obtained and evaporation of the solution yields an amorphous material probably identical with Wurtz's product.

Ethylene chlorhydrin gives nearly theoretical yields of the glycol. A typical result is the following: Twelve kilos of a solution containing 6.22 per cent ethylene chlorhydrin was treated with 835 g. sodium bicarbonate and heated for 1 hr. at 105-110 deg. C. in an autoclave. From the resulting solution 536 g. anhydrous ethylene glycol was obtained, which is equivalent to 93.5 per cent of the theoretical yield.

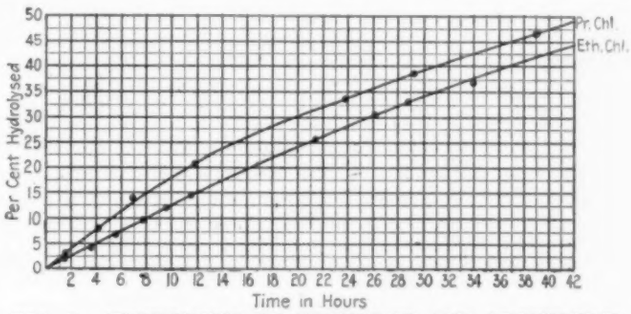


FIG. 5. HYDROLYSIS OF ETHYLENE AND PROPYLENE CHLORHYDRIN SOLUTIONS AT 97 DEG. C.

An aqueous solution containing 20.8 per cent ethylene and propylene chlorhydrins, from oil gas, the two chlorhydrins being present in nearly equal amounts, gave a slightly lower yield. Three kilos of the chlorhydrin solution, equivalent to 625 g. anhydrous chlorhydrins, and 570 g. sodium bircarbonate, yielded 403 g. glycol, or about 81.5 per cent of the theoretical. Slightly lower yields of glycol were obtained when sodium carbonate was substituted for sodium bicarbonate. To 300 g. anhydrous chlorhydrin mixture 5.5 liters of water and 180 g. sodium carbonate were added and the mixture heated for 1 hr. at 105 deg. From the solution 176 g. glycol was recovered, equivalent to 74.2 per cent.

The above processes have been carried out on a semi-industrial scale. The autoclave pressures, due chiefly to the carbon dioxide liberated, are not excessive, ranging from about 100 to 150 lb., depending upon the concentration of the solutions employed and the relative volumes of liquid and air space in the autoclave. The recovery of glycol from the saline aqueous solutions is very much the same as in the case of glycerine, except that the two glycols are much more volatile than glycerine, ethylene glycol boiling at 197.5 deg. C. and propylene glycol boiling at 188 deg. The separation between water and the glycols on distilling is therefore not so sharp as in the case of glycerine. In order to obtain water-white anhydrous glycol free from decomposition products it is necessary to distill *in vacuo*, and on a large scale the same type of still as is employed for glycerine serves admirably for the glycols. On account of the large quantities of salt in the glycol reaction mixture it is preferable to concentrate to a glycol-water ratio of about 70 : 30, when nearly all the salt is deposited. The filtered glycol may then be distilled *in vacuo* without difficulty, which practice of course is not novel, closely following the procedure common with glycerine liquors.

The author desires to express his indebtedness to Dr. J. B. Conant and Dr. James R. Norris of the U. S. Chemical Warfare Service for their many suggestions and advice.

[38] German Pat. 288,267 (1914).
[39] Henckel-Donnersmarck-Werke. German Pat. 228,867 (1907).
[40] *Z. physik. Chem.*, vol. 7, p. 337 (1891).
[41] *Ber.*, vol. 10, p. 90 (1886).

Balanced Reactions in Steel Manufacture*

An Argument That the Oxidation of Iron During Melting Is by Steam, That Iron Oxide Is Soluble in Molten Iron, and That Silicon Is Reduced From an Acid Slag by Carbon—Observations on the Composition of Gas in Blow-holes and in Solution in Solid Steel

BY ANDREW McCANCE

THERE is no satisfactory theory of the reactions which take place in the open-hearth furnace during the manufacture of steel. A general view presents several separate groups of facts with independent explanations which have not yet been connected, one with the other, in logical sequence. In this paper a rough outline is put forward of these facts considered from the standpoint of physical chemistry and of well-established theoretical principles, and the connection which exists between the final quality of the solid steel and the antecedent conditions during manufacture is traced with special reference to the contained gases. Though the author deals mainly with the open-hearth process, much of course is applicable to the other processes of steel manufacture, where the general conditions are similar in principle though different in detail.

MELTING

During the melting period in the furnace the metal is in contact with a variety of gases, such as CO_2, water vapor, nitrogen, as well as unburned oxygen and CO, with which it can react under appropriate conditions. There is one fact which guides us, however, in determining the dominant reaction from among the many complex reactions possible, and that is, that as the average temperature of melting gets lower there is greater oxidation of the scrap and consequently more FeO in the slag. Every steel-smelter knows that with a cold heat there is a more open slag and a greater tendency to go on the boil without ore than when the charge is melted hot. In terms of slag analyses, the following are two typical cases:

	FeO	SiO_2
Cold heat	36.3	36.4
Hot heat	20.8	45.0

The higher the temperature is, the rate of oxidation of the iron gets less, and possible reactions may be considered in the light of this fact.

1. The direct oxidation of the iron by the air is ruled out of account at once, since it is known that the rate at which scale forms on an iron surface increases greatly with temperature. Direct oxidation does, of course, take place, but it is not the main cause of oxide formation, but only a secondary one.

2. Oxidation by CO_2 is possible in two ways

$$Fe + CO_2 = FeO + CO - 2.3 \text{ cal.}^1 \quad (1)$$

$$3Fe + 4CO_2 = Fe_3O_4 + 4CO - 1.4 \text{ cal.} \quad (2)$$

These are balanced reactions, of which the first has been worked out fairly fully, and the composition of the gases which are in equilibrium with iron and ferrous oxide at different temperatures is as follows:

Temp., Deg. C.	CO Per Cent	CO_2	Ratio $CO:CO_2$
550	54	46	1.16
650	58	42	1.38
750	61	39	1.56
850	68	32	2.12
900	71.5	28.5	2.51

In Appendix II the author has calculated what the composition would be at higher temperatures, and finds that at 1,500 deg. it would be CO = 92.4, and CO_2 = 7.6, so that if the iron was in contact with any gas containing more than 7.6 per cent CO_2 it would be oxidized. But the burned gases in a steel furnace contain very little CO, and consequently reaction is possible. But the higher the temperature the greater will be the difference between the gases in contact and the gases in equilibrium, so that the higher the temperature the greater the oxidation.

This result can be obtained in another way by the Le Chatelier principle, for on giving the reaction heat, it must proceed so as to absorb heat. It has a negative heat of reaction, and must in consequence proceed from left to right, that is, more FeO will be formed. Exactly the same result is obtained with the second reaction, so that neither of these can be the dominant reaction during the melting period.

3. The action of steam on iron gives

$$3Fe + 4H_2O = Fe_3O_4 + 4H_2 + 38.5 \text{ cal.}^2 \quad (3)$$

With increasing temperature the amount of hydrogen gets less, and the same result follows from the Le Chatelier principle, so that the rate of oxidation is in accord with the slag condition as observed in practical working.

If the loss due to scaling is to be minimized and as little of the charge as possible is to find its way into the slag as oxides, three conditions have to be observed:

1. Melt down rapidly.
2. Melt down at high temperature.
3. Have a low steam content in the burned gases.

Nos. 1 and 2 give together hot and quick working. It is often held that during the melting-down period the temperature of the bath must be constant, since there is solid and liquid metal in contact; but this is only true if there is equilibrium, which never holds for steel-melting furnaces. So long as the liquid bath is growing at the expense of the solid scrap there is a difference in temperature between them, and the quicker the rate of melting the greater must this difference be. Pyrometer observation shows, in fact, that the temperature of the liquid bath is rising steadily during the melting period.

The presence of steam in the burned gases arises from the combustion of the hydrogen in the producer-gas together with any undecomposed steam which has passed through the producer. The composition of the gas has therefore a direct bearing on the working of the furnace and on the loss of metal due to scaling.

*A paper presented in a symposium on "The Occlusion of Gases by Metals," *Transactions* of the Faraday Society, vol. 14, p. 213.

[1]Baur and Glässner, *Z. physik. Chem.*, 1903, vol. 43, p. 354.

[2]Deville, *Liebig Ann.*, vol. 156, p. 76; Preuner, *Z. physik. Chem.*, 1904, p. 385.

As a result of this reaction the steel has an opportunity of absorbing hydrogen. There is no experimental evidence as to the extent of the solubility of hydrogen in iron in the liquid or solid state. Baraduc-Muller[3] found that the rate of evolution of hydrogen during solidification was not much greater than the rate of evolution after the steel had become completely solid. If there is little difference in the solubility in the liquid and in the solid state, it is unlikely that hydrogen is ever the cause of blow-hole formation in steel.

Boiling Period

After melting, the liquid bath has a covering of slag containing FeO and other oxides (which, however, take no part in the subsequent reactions), together with silica. Independently of how these constituents are combined one with the other, the slag can be regarded as an impure solution of ferrous oxide in silica. The addition of iron ore increases the strength of this FeO solution, and since there is no contrary evidence it must be inferred that iron oxide so added cannot act on the steel bath without first going into solution in the slag. The first action of the slag is to oxidize any Si and Mn in solution in the liquid metal; but these reactions need not be considered here, since they do not give rise to gaseous reaction products. After they have been removed, however, the carbon is attacked according to the equation

$$FeO + C = CO + Fe \qquad (4)$$

The FeO is derived from the slag, but there are many reasons for believing that the reaction is by no means confined to the surface layers of metal, but takes place equally throughout the whole mass of liquid. If the slag is scraped off during the boiling period, the metal still goes on boiling vigorously, and can do so for a considerable time, although there are only traces of slag in contact with the steel. Clean pieces of Swedish charcoal iron containing 0.16 per cent carbon lose all their carbon when melted in a magnesia crucible in an electric vacuum furnace.[4] When a local area in the bottom of an open-hearth furnace gets bad, the boil takes place much more vigorously over that area than elsewhere, and the slag may be projected some distance above the general level through the energetic action. Such facts point to the CO being liberated simultaneously throughout the mass of metal, and since the carbon is in solution, it entails that the FeO must also be in solution in the steel.

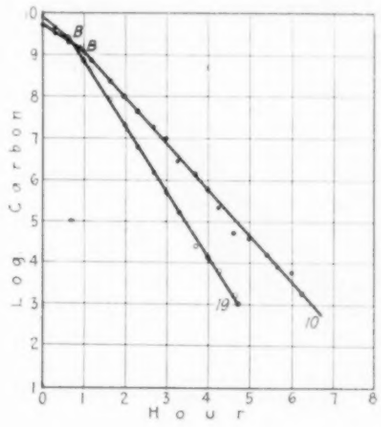
On this assumption the FeO is divided between two solvents, the slag and the steel, and the application of the partition law to such a system indicates that the concentration of the FeO in the steel must bear a constant ratio to that of the slag if the molecular condition of both solutions be the same. If FeO in the steel be removed from solution, then more FeO will pass from the slag into the steel, until a balance is once more obtained, and if the FeO be continuously removed, then a continuous flow of FeO will come from the slag and will endeavor to replace the loss. If no addition of FeO be made to the slag (in the form of iron ore), then the percentage content will fall continuously.

The mechanism of the carbon reduction in the open-hearth process can now be understood, for as the ore is added to the slag it dissolves as FeO, which is transferred in solution to the bath, and reduced by the carbon there with the production of CO. The reaction will follow the laws of chemical kinetics, so that, stating the concentration of the FeO in the slag as C_{FeO}, the concentration in the steel will be aC_{FeO}, where a is the partition coefficient. If C_C and C_{CO} stand for the corresponding concentrations of the carbon and the carbon monoxide, the reaction velocity will be

$$\frac{dx}{dt} = K(aC_{FeO} - x)(C_C - x) - k(C_{CO} - x) \qquad (5)$$

where K and k are constants.

The carbon monoxide which is first given off dissolves in the steel, but whenever the steel becomes saturated the excess gas will escape into the atmosphere. This is the commencement of the boil. The steel from this moment is therefore saturated with gas, so that the CO term in equation (5) can be neglected. On integrating, this equation takes the usual logarithmic form, and the log of carbon against time should plot a straight



line. It is to be remembered at this stage that this will only be true if no external addition is made to the FeO after the reaction starts—that is, if no ore is added to the charge after the boil commences. The accompanying figure gives curves taken from results obtained by the author. Samples were taken every 20 min. during the course of two acid open-hearth charges from the time the metal was melted until it was tapped out. It will be seen that the straight line fits the points surprisingly well, considering that in a melting furnace under steelworks conditions it is impossible to keep other complex influences constant, as the theory assumes.

The curves are interesting in another way, for each really consists of two parts. The first part relates to the loss of carbon before the boil commences, when the bath still contains some silicon and manganese. The commencement of the boil is marked by a distinct angle between the two parts of the curve, and the rate of loss of carbon when the other elements are present is much less than when they are absent.

As the carbon in the bath gets less, the rate at which it is being reduced also gets less, until it ultimately becomes of the same order of magnitude as the rate of the reverse reaction brought about by the presence of the CO. When it becomes equal to the latter, then equilibrium is established and no further carbon is oxidized. When this takes place, equation (5) reduces itself to

$$\text{Constant } \frac{K}{k} = \frac{C_{CO}}{aC_{FeO}C_C} \qquad (6)$$

[3] *Jour. Iron and Steel Inst., Car. Res. Mems.*, 1914, p. 216.
[4] Yensen, *Bull. Illinois Univers.*, No. 72, p. 41.

How far the attainment of equilibrium is possible in a melting furnace is a difficult question to decide. The carbon, for one thing, is never constant, but is always dropping slowly, and the time element in practical working necessitates the adoption of other means for controlling the oxides in solution. But the conditions, however they may vary, are always trying to approach equilibrium, and alterations in the external conditions will have the same effect whether it is attained or not.

Since the steel is saturated, the upper term will remain constant in equation (6), and so the lower the carbon in the steel at the final stage, other things being equal, the higher the amount of FeO and vice versa, which accounts for the fact that mild steels are more difficult to deoxidize than higher carbon steels made under the same conditions.

Supposing lime is added to a slag which is in equilibrium with the metal underneath, then the FeO concentration of the slag is reduced and the metal is no longer in equilibrium, but contains excess FeO which will act on the carbon available until equilibrium is once more attained. For this reason CaO can replace ore with advantage toward the end of the boil, but it is obvious that this action cannot take place at the beginning of the boil, since the effect would then be directly opposite and it would retard oxidation. Any diluent, such as manganese ore, magnesia, etc., would act exactly in the same manner.

The influence of temperature is very important, and in the author's opinion it is the one method of control which is neglected in practical steel-making. It is not sufficient to tap a charge which leaves no ladle skull and possesses an excess of heat which is irregular and varies from charge to charge. Much more than that is implied by "temperature control." It is the production of charges of steel which have been worked in the furnace, and which have been cast with a constant and known amount of superheat over the temperature of solidification.

In Appendix I the calculations are given which show that for a variation of 50 deg. in the finishing temperature a decrease of more than 33 per cent is possible in the amount of FeO which the steel carries in solution. The author has already shown the great influence which this fact has on the number of non-metallic inclusions present in the finished steel.[4] The reduction in the FeO content of the steel with rising temperature reacts correspondingly on the slag, with the well-known result of thickening it. High temperature working gives siliceous slags.

Reduction of Silicon

With a highly siliceous slag in contact with iron and carbon, reduction of the silica may take place in two possible ways:

$$SiO_2 + 2C = Si + 2CO - 122 \text{ cal.} \quad (7)$$

$$SiO_2 + 2Fe = Si + 2FeO - 51 \text{ cal.} \quad (8)$$

and in both an increase in temperature will lead to a greater reduction and the formation of more silicon.

From the results of a large number of estimations the author has found that in acid open-hearth working the reduction of silicon during the finishing stages, when the carbon is in the region of 0.15 to 0.20 per cent, is practically negligible. It is within the limits of chemical error. In acid electric-furnace work, on the other hand, it is quite appreciable, and it is possible to reduce 0.2-0.3 per cent direct from the slag. In crucible melting, the killing of the melt results from the reduction of the silica of the clay pot, but crucible charges are usually high in carbon, and it is much more difficult to kill low carbon charges in this manner. The experiments of MacWilliam and Hatfield[5] showed that this reduction may be brought about in open-hearth furnaces, but it is noticeable in their figures that when reduction takes place the carbon is about 0.40 per cent.

It is fairly evident, therefore, that it is the carbon which reduces the silica and not the iron. The reverse reaction in equation (8) is important when additions of silicon are made later for deoxidation purposes.

Manganese behaves similarly, and need not be considered separately.

Carbon Monoxide

The presence of CO in solution in iron entails a further reaction with the FeO

$$FeO + CO = CO_2 + Fe \quad (9)$$

a reaction which has been studied over a considerable range by Baur and Glässner[7] for solid Fe and FeO. Their results, however, will not enable us to arrive at quantitative conclusions regarding the equilibrium of the same materials when they are in a state of solution. Qualitative deductions in accordance with experimental facts can, however, be made. This equilibrium is independent of pressure, and the ratio of $CO:CO_2$ under reduced pressure is therefore constant. This is shown by the results of Baraduc-Muller[8] in the composition of gas drawn off an ingot in four periods between the time of casting and the solidification of the metal:

No.	CO	CO_2	Ratio $CO:CO_2$
1	43.2	5.2	8.3
2	56.8	4.0	14.2
3	40.8	4.8	8.5
4	24.8	2.8	8.8

Excepting No. 2, the constancy is extremely good when the difficulties of the experiment are remembered.

A lowering of the temperature of working greatly decreases the ratio (see Appendix II). Thus in cast iron[9]

Cast. Temp.	Ratio $CO:CO_2$
1,428	30.2
1,348	13.7
1,264	7.2

The bearing which this has will be considered in the next section.

The Formation of Blow-Holes

It is a general law that the solubility of gases in liquids increases as the temperature is lowered, but at the freezing point the solubility is much less in the solid state than in the liquid condition. As a result, all gases will show strongly the effects of primary segregation—that is, the concentration of the solution in the last portions to solidify. If during the progress of this concentration the limit of solubility is reached, then the excess gas will escape and blow-holes will be formed. At the finishing stages in the open-hearth furnace, as previously explained, the steel is saturated with CO and the amount of gas will depend only on the temperature. If this is constant, then all steels will start with the same amount of gas in solution. Starting, then, with a quantity of liquid steel containing CO and CO_2, and

[4] *Journ. Iron and Steel Inst.*, 1918, part 1, p. 289.

[5] *Ibid.*, 1902, part 1, p. 54.

[7] *Z. physik, Chem.*, 1903, vol. 43, p. 461.

[8] *Jour. Iron and Steel Inst., C. S. M.*, 1914, p. 216.

[9] *Jour. Iron and Steel Inst., C. S. M.*, 1916, p. 66.

neglecting for the moment all other reactions except (9), cooling will result in more CO_2 being formed at the expense of the CO. But the steel in the solid state may have a very limited solubility for CO_2, and if this be exceeded, blow-holes will be formed at the instant of solidification. The formation of blow-holes not only depends on the quantity of dissolved gas but also on the variety of gas. No attention has hitherto been paid to this possibility, and to explain all the peculiarities in the relations between these gases and steel it is only necessary to assume that steel in the solid state has a much greater solubility for CO than for CO_2.

When equilibrium is established according to equation (9)

$$K = \frac{C_{CO_2}}{C_{FeO} \cdot C_{CO}}.$$

When there is much ferrous oxide in solution, the ratio CO_2:CO will be correspondingly great, and when the steel solidifies, if the amount of CO_2 is greater than the metal can hold in the dissolved state, blow-holes will be formed. If on the other hand the ferrous oxide be removed, the amount of CO_2 will shrink until the ratio CO_2:CO corresponds to give the correct value of K, and on solidification the saturation limit may never be attained. It is important to notice that the total volume of gas (expressed as c.c. per g. of metal) may remain quite unaltered by the reduction of the FeO, so long as direct reduction of the gases does not take place. How well this accords with the experimentally determined volumes of gas by different observers will be seen by the following results. Boylston,[10] using all the well-known deoxidizers, found

	C.c. per 100 g.
Average for deoxidized metal	126
Average for oxidized metal	125

Goerens,[11] using quite a different method for the estimation of the gas, gives the mean of two charges in a basic open-hearth furnace, the samples being taken from the bath before and after deoxidation

	C.c. per 100 g.
Average before deoxidation	67
Average after deoxidation	88

Baker,[12] from two similarly melted charges of crucible steel

	C.c. per 100 g.
Steel without blow-holes	132
Steel with blow-holes	67

With regard to the latter, the two charges were melted in separate pots at the same time, and it is admittedly difficult to determine similarity of condition during melting so far as gas content is concerned.

It may, however, be taken as proved that deoxidation does not necessarily mean the diminution of the total gas in solution.

Since deoxidized steel contains less FeO, the gas given off should have a higher CO_2:CO ratio than oxidized steel, and the results of Goerens again enable this to be confirmed. Taking samples from two electric-furnace charges after the removal of the phosphorus slag and again after deoxidation with ferrosilicon and ferromanganese, and extracting the gas, it was found

	CO_2:CO Ratio per Cent	
Before deoxidation	8.8	7.3
After deoxidation	60.0	21.3

In the first charge the manganese was 0.08 per cent and in the second 0.13 per cent at the time of taking the first sample, showing that the former was in a more highly oxidized state than the latter, and consequently it gives a greater difference after deoxidation. The theoretical deductions are strikingly confirmed.

As calculated in Appendix II, the composition of the gas in equilibrium with solid iron and FeO at the solidifying temperature, taken as 1,500 deg. C., is roughly CO_2 = 7.8 per cent, CO = 92.4 per cent, so that even if pure CO_2 were given off from the solidifying steel it would immediately be reduced again to CO by reaction with the solid iron until the composition of the gas approached this value. The fact that the gas liberated from an ingot burns with the blue flame of CO does not imply that it was given off as such during the solidification.

Estimation of Gases in Steel

In steel, from what has previously been said, the gas content in the solid state will be proportional to the gas content in the liquid solution, but the determination of the exact composition and quantity of this gas presents grave practical difficulties.

Two methods only so far have been used—the extraction of the gas by heating the sample in a vacuum (Baker, Boylston, Donaldson, etc.) and the fusing of the sample in a vacuum with tin and antimony, which have practically no dissolved gas themselves (Goerens). In the first method, any gas which is evolved which does not possess the composition necessary for equilibrium according to equation (7) for the temperature of the experiment will tend to react with the steel until it does possess that composition. Thus the composition found must have been modified in a quite indeterminate manner by reaction taking place at a lower temperature. The sum of the volumes of CO_2 and CO, however, gives the exact volume of the mixed gases at the temperature of solidification. The composition may not be the same.

With regard to the second method, the carbon contained in the steel is insoluble in the alloy and floats to the surface, where it remains, at the same time reducing the CO_2 in accordance with the reaction

$$CO_2 + C = 2CO \qquad (10)$$

This reaction not only varies with the temperature but also with the pressure of the gases, so that the results obtained only give the volume of the gas originally contained exactly, when expressed as CO_2 equivalent. That is, the volume of CO_2 plus ½(volume of CO) gives exactly the volume of mixed gases originally contained by the steel.

How far the composition is altered depends on the rate of evolution, so that the effect is merely to mask the differences in composition by an uncertain amount. Qualitative deductions can, however, still be drawn from the results, and it is the object of this paper to show how such deductions give an insight into the complex conditions existing in liquid steel during manufacture.

Appendix I

The heat of reaction at ordinary temperatures for the reaction

$$FeO + C = CO + Fe - 35.6 \text{ cal.}$$

is −35.6 cal., and the heat of reaction at the temperature of a melting-furnace, 1,600 deg. C., can be calculated in the following manner:

[10] *Jour. Iron and Steel Inst., C. S. M.*, 1910, p. 157.
[11] *Ferrum*, vol. 12, p. 78.
[12] *Jour. Iron and Steel Inst., C. S. M.*, 1902, p. 224.

From Nernst's theorem, using the accepted symbols

$$Q = Q_o + \beta T^2$$
$$\frac{dQ}{dT} = 2\beta T = C_r - C_p.$$

There are no measurements of the molecular heat of ferrous oxide, since it has never been isolated pure, but Richards gives the value at 0 deg. C. of the specific heat of

Fe_2O_3 as 0.1456
Fe_3O_4 as 0.1447

so it can be assumed that the specific heat of FeO is in the neighborhood of 0.145, which gives a molecular heat of 10.45.

Mol. heat of carbon at 17 deg. C.	1.92
Mol. heat of CO at 17 deg. C.	6.71
Mol. heat of Fe at 17 deg. C.	6.15

(These values are calculated from Kaye and Laby, *Physical Constants.*) From these results,

$$C_r - C_p = 12.37 - 12.86 = -0.49 = 2\beta T,$$

and since the values were calculated at 290 abs.

$$\beta = -9.0 \times 10^{-4}$$

At $T = 290$ deg. abs., $Q = -35{,}600$, so that at $T = 1{,}873$, $Q = -38{,}700$. The difference is therefore negligible, and no appreciable error is introduced by taking the values at ordinary temperatures.

To find the difference in the value of the equilibrium constant K

$$\frac{d}{dt} \log K = -\frac{Q}{RT^2} \qquad (11)$$

and on integrating

$$\log \frac{K_1}{K_2} = -\frac{Q}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right).$$

The ratio between the value of K at 1,600 deg. C. and K at 1,550 deg. C. is consequently

$$\log \frac{K_1}{K_2} = \frac{38{,}700 \times 50}{2 \times 2.30 \times 1{,}873 \times 1{,}823} = 0.124$$
$$\frac{K_1}{K_2} = 1.33.$$

Since $K = \frac{C_{CO}}{C_{FeO} C_C}$, an increase in K implies an increase in CO or a diminution in the product of the bottom terms. The steel is, however, saturated with CO, and, like all gases in solution, the saturation strength must diminish very considerably with a rise in temperature. At the finishing stage, pigging back is usually started when the carbon is in the neighborhood of 0.17 to 0.20, so that the carbon concentration is practically constant and independent of other conditions. An increase in the value of the equilibrium constant of 33 per cent, as found above, means a reduction in the amount of ferrous oxide in solution of more than 33 per cent.

Appendix II.

The reaction

$$FeO + CO = CO_2 + Fe_1 + 3.7 \text{ cal.}$$

can be treated in exactly the same manner as the previous reaction in Appendix I, but it presents some peculiar features. To begin with, the log K from Baur and Glässner's results plotted with $1/T$ does not give a straight line, which implies that Q varies with temperature to an appreciable extent.

The heat of reaction at ordinary temperatures is $+3{,}700$ cal. and the molecular heat of CO_2 is 8.9. This gives, as before

$$2\beta T = C_r - C_p = 17.16 - 15.05 = 2.11,$$
$$\therefore \beta = 3.6 \times 10^{-3}$$

This value is unusually high. At 825 deg. C. the heat of reaction Q_{825} is

$$Q_{825} = 3{,}400 + \beta(1{,}098)^2 = 7{,}750 \text{ cal.}$$

The equilibrium constant K has the following values:

750 deg. C.	1.56
900 deg. C.	2.51

which, calculating back by means of equation (8), Appendix I, gives

$$Q_{825} = 7{,}650 \text{ cal.}$$

This agrees very well with the previous value, found by quite a different method.

Substituting $Q_o + \beta T^2$ in the integration of equation (11), Appendix I, the value of K at different temperatures will be:

1,200 deg. C.	5.8
1,300 deg. C.	7.5
1,400 deg. C.	9.5
1,500 deg. C.	12.1
1,600 deg. C.	15.2

The gas given off from a steel ingot immediately after solidification gave a ratio for K of 11.0,[13] and at lower temperatures 3.1 to 4.2. In the former case the temperature cannot have been far removed from the temperature of solidification, which was in the neighborhood of 1,475 deg., and in the latter case the temperatures were probably about 700 to 800 deg. C. These figures show the great importance of equilibrium conditions, and support the contentions of the author regarding the methods of estimating the gases in solution in steel.

Northwest Magnesite Co. Not a Monopoly

One of the principal arguments used against tariff on magnesite before the Ways and Means Committee was that the magnesite production of the United States is in the hands of the Northwest Magnesite Co. This concern was characterized as a monopoly. This charge is declared by Roy N. Bishop, general manager of the Northwest Magnesite Co., as being entirely unjustified. In the hearings on magnesite before the Senate Finance Committee Mr. Bishop said in that connection:

"Because we put $750,000 into a plant and developed magnesite so badly needed by the country during the war, we were charged in the previous hearings before the Ways and Means Committee with being a monopoly. A complete refutation of that is that we own only one-eighth of the raw material in the United States and that we never have produced more than 35 per cent of the magnesite that has been produced in the United States. As soon as a tariff is granted on it, those who own the other seven-eighths of the raw material will become very active competitors."

The cost of magnesite to the Northwest company, Mr. Bishop testified, is a little over $21 a ton. He declared that the company had sold at that price during the war, but "the people to whom we sold it in turn sold it to the steel companies with an addition of about $10 a ton to our price. For practically indorsing the bill of lading, they made a greater profit out of the magnesite than we did."

[13] Baraduc-Muller, *loc. cit.*

The Sterilization of Water by Means of Ultra-Violet Rays*

Records and Information on Potable Water Installation for Isolated Plant Supply—Fluctuations of Bacteria Counts in Raw Water — Exposure Required for Ray Sterilization — Water Consumption Rates and Quantities per Capita — Capacity of Ultra-Violet Ray Apparatus

By WALTER L. DECKER†

SCANNING the pages of history, we note that time after time this and that community has been visited by some dire epidemic which has caused the death of thousands and thousands of people. Failing to realize the cause, it was often attributed to the wrath of God. Having run its course and passed away, people settled down again to their former mode of existence.

With advancing knowledge and research, investigators began to doubt the wrath of God theory and began, by the process of elimination, the systematic study of cause and effect. Eventually it was found and proved that the water used by the community was the cause of the trouble. Chemical analysis failing to show the presence of any deleterious salts in the water that would cause sickness, resort was had to the microscope. This finally revealed the presence of certain organisms, invisible to the naked eye, which if eliminated from the water removed the cause of the trouble.

Suitable Drinking Water

Our former ideas of a suitable drinking water must be modified. Water may appear clear, cool and sparkling and yet contain organisms which are inimical to one's health.

A pure water may be defined as one which contains no disease-producing bacteria or an excess of organic matter of any kind. An impure water is generally defined as one which receives more or less sewage, one therefore that is not fit for human consumption. A pure water supply is one of the best safeguards of the health of a community. A relatively small number of diseases are transmitted by impure water. These diseases are typhoid fever, dysentery and Asiatic cholera. A pure water supply seems to affect the general health of a community and to decrease its death rate wholly apart from the decrease due to the elimination of the specific diseases mentioned. This is doubtless due to the fact that the impure water so affects the average health of a community that the individuals become more readily susceptible to other diseases.

The increased growth of our cities, with increased contamination of our water supplies, has brought about a general awakening of the community to the importance of the arts of sanitation. Bacteriology has ceased to be a subject of interest and importance to the medical profession only, but has become intimately connected with the work of the chemist, the biologist and the engineer. To the sanitary engineer the subject of bacteriology is indispensable.

Micro-Organic Life

Bacteria are the most numerous and the most widely distributed of living things. They are found in the surface of the earth, in the water under the earth, and in the air above the earth. Wherever there is life, waste matter is constantly being produced, and this finds its way to the earth or to some body of water. The excretions of animals, the dead tissues and broken down cells of both animals and plants, as well as the wastes of domestic and industrial life, all eventually find their way to the soil. In a majority of cases these substances are not of such chemical composition that they can be utilized at once by green plants as food, but it is first necessary that they go through a decomposition or transformation in which their chemical nature becomes changed, and it is as the agents of this transformation that bacteria assume their greatest importance in the world of life. When a bacterium cannot multiply, the only vital activity which can take place is a katabolic wasting away, which soon proves destructive, and the higher the temperature the more rapidly the fatal result is reached.

Bacteriology may be defined as that branch of science which treats of the forms, functions and activities of bacteria. The lines of demarcation between bacteria, yeasts, and molds of the vegetable kingdom, and certain protozoa of the animal kingdom are very poorly marked. It is not difficult to differentiate between the higher animals and plants, since there are many points of contrast plainly to be seen. With the microscopic organisms much greater difficulty is experienced, and some intermediate forms are known that constitute a complete series of intergradations between the two groups.

Types and Growth of Micro-Organisms

Four types of cells are found among bacteria: spherical, rod shaped, spiral and filamentous, these in turn being called coccus, bacillus, spirillum, and trichobacteria. All bacteria multiply in but one way, by a simple splitting of a cell into two. This may be termed vegetative reproduction. Some bacteria produce specialized resistant cells fitted to reproduce the species after a period unfavorable for growth. These are termed spores.

Chemicals may stimulate the growth of an organism, they may partially or completely inhibit its growth, or they may destroy it. Thus, a germicide is any substance which will kill micro-organisms, and an antiseptic is one which inhibits their growth without necessarily destroying them.

In general it may be stated that the plant cell differs from that of the animal by the possession of a firm and well differentiated wall, wholly distinct from the contained protoplasm. The typical cell wall of plants is made up of cellulose; the limiting membrane of the animal cell is nitrogenous.

Plenciz first clearly stated the germ theory of disease in 1762, claiming that each disease was caused by a particular kind of organism. This relationship was

*A paper read before the Cleveland Engineering Society, January, 1920.

†Construction Engineer, The American Shipbuilding Co.

later worked out more satisfactorily by Pasteur, Koch and Weigert.

Bacteria live upon organic matter, taking in oxygen and giving out carbonic acid. In the absence of dissolved oxygen gas in water they take their oxygen from the organic matter itself; that is, they decompose it, giving out not only carbonic acid, but also carbon monoxide, methane and other gases. This process has been sometimes called anaërobic respiration, that is, respiration without air. It is also called putrefaction.

Bacteria in Water and Their Quantitative Determination

Sedimentation is only one method by which bacteria are removed from water. We find that the bacteria furnish food for the protozoa; they in turn provide food for the rotifera and crustacea; they in turn are consumed by fish; and fish in turn provide food for men. Pathogenic germs when scattered through a mass of water cannot be detected by ordinary microscopical methods on account of their small size and because they

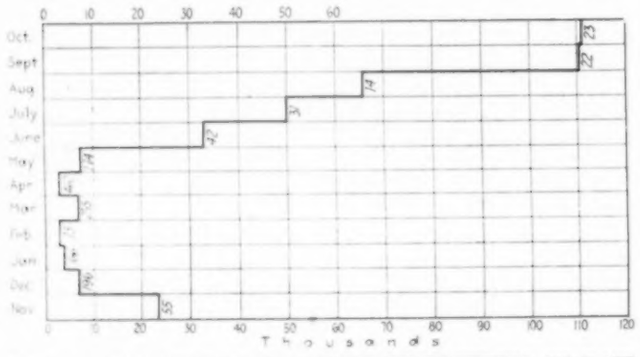


FIG. 1. MONTHLY FLUCTUATION OF BACTERIA IN RAW WATER AT WYANDOTTE

are greatly outnumbered by the ordinary water bacteria. Perhaps the most important service that the microscopical examination renders is that of explaining the cause of the taste and odor of water and its color. The microscopic organisms found in water show variations in their seasonal occurrence as great and almost as characteristic as those of land plants.

The *Bacillus coli* is a normal inhabitant of the intestinal tract of man and many other animals, and occurs regularly in their excreta, and on this account it is of the highest importance to sanitarians, since its presence in water supplies is a direct evidence of sewage pollution. Specific disease germs are difficult to isolate even when they are present, and water may be grossly polluted with sewage without any specific disease germs being present. All sewage pollution, however, is potentially dangerous, since where fecal matter exists, disease germs are at any time likely to be present.

A test for fecal matter as distinguished from infected material is therefore essential, and for such a test the colon group of bacilli are especially well suited. They are not dangerous in themselves, but they are significant indices of the probable presence of disease germs. What we dread in drinking water is the presence of pathogenic bacteria, mainly from the intestinal tract of man, and it is quite certain that the related nonpathogenic bacteria from the same source will behave more nearly as these disease germs do than will any chemical compound.

The procedure for the quantitative determination of bacteria in water consists in mixing a definite amount of a suitably collected specimen of the water with a sterile solidifiable culture medium and incubating it for a sufficiently long time to permit reproduction of the bacteria and the formation of visible colonies which may be counted. The typhoid bacillus and the colon bacillus stand at the opposite ends of a series of many different varieties of organisms which are intermediate in their properties, which produce a more or less characteristic growth on solid media.

Wyandotte (Mich.) Drinking Water Supply

It was during the height of the German drive in 1918, when all of us at home were diligently striving for increased production or increased means for production, that the question of an adequate supply of drinking water arose at the Wyandotte plant of the American Shipbuilding Co., Wyandotte, Mich.

At the time, the writer was engaged in supervising the construction of some fifty-odd buildings at the various plants of the company. Lack of time prevented him from giving the subject the amount of thought and study which it merited. It was a case where decision must be made at once and the results left to the hope of future accomplishment. Due to continual sickness in Wyandotte and to the fact that another thousand employees must be added to this plant at the earliest possible moment, it became necessary, more than ever, to give some thought toward the prevention of sickness among such a body of men if the work was not to be delayed by their enforced absence.

Due to its adverse location just below Detroit, and due to Detroit's rapidly increased growth and population, the increased amount of sewage that was dumped into the Detroit River rendered Wyandotte's problem of an adequate source of drinking water a more and more perplexing problem. Wyandotte was taking its source of water directly from the Detroit River and treating same with bleaching powder before distribution in its city mains. On account of excessive contamination and the lack of a filtration basin the amount of chlorine that had to be used was exceedingly high. The water as a rule smelled and tasted of chlorine, which made its use objectionable from more than one standpoint. Fig. 1, showing a comparison of the contamination of the Detroit River above and below Detroit, gives a clear idea of Wyandotte's problem. The curve shows the monthly fluctuation of the average number of bacteria in the raw water and the numbers on the curve show for comparison the average number of bacteria as found in the raw water supply of the city of Detroit.

Sterilization With Chlorine

Chlorine as a disinfectant was first used about the year 1800, and hypochlorite of lime (bleaching powder) as early as 1854 was used by the English Royal Commission for deodorizing the sewage of London. The first practical use of chlorine in water treatment in this country was in 1908, when Johnson used hypochlorite of lime in the treatment of the Bubbly Creek water at the Union Stock Yards in Chicago. After treatment and filtration, laboratory tests showed the effluent from the filters to be more nearly free from pathogenic bacteria than the water being furnished to the City of Chicago taken from Lake Michigan long distances from the shore. At present over 1,000 cities are treating their water supplies with either chlorine or hypochlorite of lime.

Laboratory experiments indicate that there is little

difference in the effectiveness of hypochlorite of lime and liquid chlorine as a sterilizing agent, but on account of losses in handling and mixing the bleach it requires a larger amount of chlorine in the bleach treatment than when liquid chlorine is used. In treating a water supply which is to be used largely for domestic purposes it must be considered that one of the primary qualities required in such a supply is an agreeable taste, and any treatment which cannot make water safe for drinking purposes without causing a disagreeable taste cannot be considered a successful and satisfactory method of treatment.

Since 1913, when the first commercial liquid chlorine machines were used, the popularity of this process has increased in a remarkable manner. Prior to this, water supplies were treated mainly with hypochlorite of lime. This process requires the use of mixing tanks for mixing the hypochlorite with water to a creamy consistency; storage tanks for holding the day's supply of chemical; and mixing tanks for regulating the amount of solution that is to be added to the raw water. The discharge of the hypochlorite solution is usually regulated either by maintaining a constant head on an orifice of variable dimension or by varying the head on an orifice of fixed dimension. Sludge is continually being formed in the storage tanks and the depth of same must be kept below the discharge outlet to prevent plugging of the pipe lines and measuring devices. For a small plant the bleach treatment is out of the question, as a trained chemist must be kept in attendance at all times in order to test the strength of each solution as it is made up.

PERCENTAGE REDUCTION, 15 MIN. CONTACT

Available Chlorine p.p.m.	Nature of Test Organism: *B. Cloacae*	*B. Faecalis Alkaligenes*	*B. Paratyphosus*	*Proteus Mirabilis*	*B. Enteritidis*	*B. Lactis Aerogenes*	*B. Choleraesuis*
0.1	.....	99.98	.....	27.3	.....	.....	.....
0.2	99.69	99.99	99.97	45.5	99.83	99.17	95.8
0.3	99.75	100.00	100.00	63.7	99.98	99.98	100.0
0.5	100.00	.....	.....	72.7	100.00	100.00	.....
0.7	.....	.....	.....	63.7	.....	.....	.....
1.0	.....	.....	.....	63.7	.....	.....	.....
3.0	.....	.....	.....	90.9	.....	.....	.....
5.0	.....	.....	.....	90.0	.....	.....	.....
Original number of organisms per c.c.	160,000	9,500	3,000	8,000	180,000	180,000	500

The dosage or amount of chlorine to be added to raw water depends upon the following four points:

Content of readily oxidizable matter.

Temperature of water.

Method of application.

Contact period.

The amount of chlorine required for germicidal action is small and tests made by Race show that 1,000 *B. coli* per c.c. in absence of organic matter can be reduced to two *B. coli* per 100 c.c. (the U. S. Government standard) by 0.1 p.p.m. of available chlorine in 10 min. at 65 deg. The accompanying table shows the results of tests by Lederer and Bachmann upon the percentage reduction of various bacteria with a 15-min. contact period.

There is no marked difference in the resistance of ordinary water bacteria to chlorine, and the common intestinal organisms are also very susceptible to destruction by chlorine. The spore-forming bacteria usually found in water are derived largely from soil washings and from sewage and manure. The spores of these organisms are very resistant and survive all ordinary concentrations. In practice no attempt is made to destroy the spore-bearing organisms, as they have no sanitary significance and the concentration of chlorine required for their destruction would cause complaints as to tastes and odors if the excess of chlorine were not removed.

Action of Ultra-Violet Rays

What was desired at our Wyandotte plant was some system that would do away with this constant supervision, some system that would function day and night, whether the incoming water contained 100 bacteria or 100,000 per c.c. Upon inquiry, I found that there was such a system in existence, but that little reliance or faith was placed in it. To me the system appeared of value and I felt that the fault was mainly due to its practical application.

In order to have a better understanding of the system, we will revert back to the experiment that used to be performed in the physical laboratory. If a ray of sunlight, which appears white to the eye, is allowed to fall on a prism we have projected on the screen a succession of various colors called the spectrum. According to their refrangability the colors are arranged with violet the highest, then blue, green, yellow, orange and red as shown in Fig. 2.

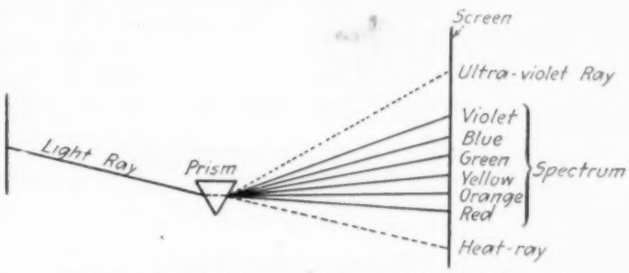


FIG. 2. DISSOCIATION OF SUNLIGHT INTO ITS PRIMARY COLORS

The vibrations of the ether are capable of producing other effects besides illumination. They constitute what is called radiant heat, and they are also capable of producing chemical effects, as in photography. Vibrations of high frequency are the most active chemically, those of low frequency have usually the most powerful heating effects. The color of lowest pitch is deep red, its frequency being about 400 million million vibrations per sec. The color of highest pitch is deep violet, its frequency being about 700 million million vibrations per sec. Fig. 3 shows a comparison of the frequency of vibration of the light waves with other invisible waves. Dividing the velocity of transmission (188,000 miles per sec.) by the various frequencies gives us the wave length of the various waves. Almost every source of light produces with the visible rays some wave lengths shorter than those which are perceptible to our eyes, these being called ultra-violet rays.

In so far as when intercepted they are converted into heat, all rays are heat rays, but neither the ultra-violet nor any other radiation is heat, but it may become heat when it ceases to be a radiation. Thus all radiations are chemical rays if they strike a body which is responsive to them. When a beam of radiation impinges upon a body it is resolved into three parts: one part is reflected, one part absorbed (converted into heat energy or chemical energy or some other frequency of radiation), and one part passes through and out of the body if it is not too thick. No body reflects, or absorbs, or transmits all the radiation, as even the most perfectly reflecting body absorbs and transmits some radiation.

The ultra-violet rays are extremely destructive to the eye; exposure even to a moderate intensity of them for a very few minutes produces a severe and painful inflammation, the after effects of which last for years, and long exposure would probably result in blindness.

Radiation impinging on the tissue of the human body or other living organisms exerts an influence depending on the intensity, power and frequency. The effect of radiation on the living protoplasm of the cells is stimulating if of moderate intensity, destructive if of excessive intensity. The intensity of light which is destructive to life largely depends on the amount of light to which the organism is accustomed. Those organisms that live in the dark may be killed by an amount of light which is necessary for the life of other organisms.

As men have lived for ages in the light, the cells of the human body are far more resisting to the light than the disease germs, which for ages have lived in the dark. Light, and more particularly the high frequency ultra-violet and the X-rays, thus have found a useful application in killing disease germs in the human body.

That the chemical activity of radiation is some form of resonance is made probable by the relation which exists between the active frequency and the weight of

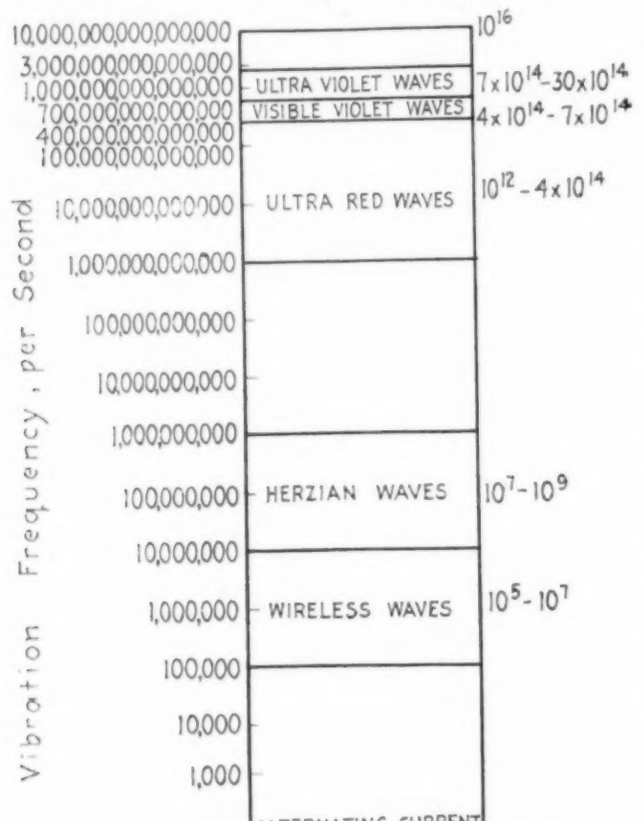


FIG. 3. COMPARISON OF VARIATION FREQUENCY OF DIFFERENT WAVES

the atom or molecule which responds to vibration. Thus, while the fairly heavy silver atom (atomic weight 108) responds to rays near the violet end of the spectrum, the much lighter oxygen atom (atomic weight 16) responds only to much higher frequencies. These very short radiations energetically produce ozone (O_3) by dissociating some of the oxygen molecules (O_2) into free atoms, and these free atoms then join existing molecules to form ozone.

Response to long waves of red and ultra-red light thus may be expected from atoms or groups of atoms which are very much heavier than the silver atom, and this indeed seems to be the case in the action of radiation on the life of plants. Those parts of the plants which contain chlorophyll, mainly the leaves, take carbon dioxide (CO_2) from the air through breathing openings, absorb the radiation and convert its energy into chem-

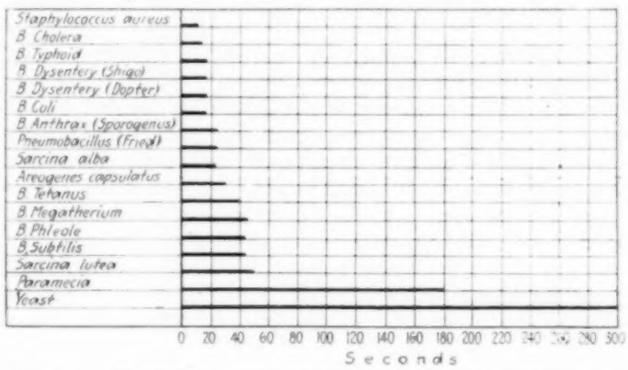


FIG. 4. SECONDS NECESSARY TO KILL DIFFERENT TYPES OF GERMS AT 200 MM. FROM A QUARTZ LAMP OPERATING AT 66 VOLTS, 3.5 AMPS.

ical energy, and use this energy in splitting up CO_2, exhausting the oxygen and using the carbon in producing the complex carbon compounds of their structure.

Sterilization With Ultra-Violet Rays

Ward was the first to demonstrate that the typical characteristic of ultra-violet light is the bactericidal power of these radiations. He threw the spectrum on an infected agar plate with the result that the parts of the plate which were exposed to the violet end of the spectrum did not show any growth of colonies, while the parts which were exposed to the red end of the spectrum developed growth.

The great source of ultra-violet radiations is the sun. Rivers and lakes are freed from a great part of their bacterial contents by the bactericidal power contained in the sun's rays. Small amounts of ultra-violet are produced by practically all artificial light sources. Electric discharges between metal electrodes are powerful producers of ultra-violet radiations. The disintegrated metal has to be replaced after being volatilized by the heat of the arc. The replacement is easiest if the disintegrated metal condenses easily and can be made to flow back, as is the case if mercury is chosen as electrode. The material in which the arc is enclosed has to be transparent to the discharge of ultra-violet rays. The only industrial material filling this demand is fused quartz. Glass which is transparent for visible light is nearly opaque

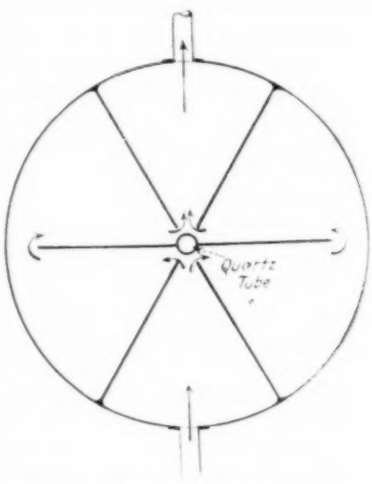


FIG. 5. ARRANGEMENT OF BAFFLES IN STIRRING APPARATUS

to ultra-violet light, hence cannot be used for this purpose.

The next step then was to determine whether ultra-violet rays would sterilize water. Accordingly various germs were placed in clear water and subjected to the action of these rays, and the length of time of exposure necessary to kill the various germs is shown in Fig. 4. Experiments have demonstrated that as the mercury vapor lamp can be run at different temperatures, by increasing or decreasing the voltage on the electrodes, its destructiveness of bacterial life is accordingly increased or decreased. An increase in watts, that is to say, of temperature, produced a much greater increase of the red and yellow than of the blue and violet, but it was found that the ultra-violet end of the spectrum increases about like the red end.

Water, if clear, is practically as transparent as air to ultra-violet rays. In many cases, however, it must first be filtered to free it from suspended matter and, if possible, also from colloidal matter, which would otherwise retard the passage of the rays. Careful observation of well-filtered water, however, nearly always reveals the presence of a small amount of suspended matter of a large enough size to allow microbes to be protected against the rays. To sterilize such water with safety it was found advantageous to agitate it while passing through the illuminated zone and to expose it several times to the light of the same lamp. This stirring up is best accomplished by a proper arrangement of baffles in the apparatus as shown in Fig. 5.

Having decided to try out this system of sterilization, the next point was to determine what system of records

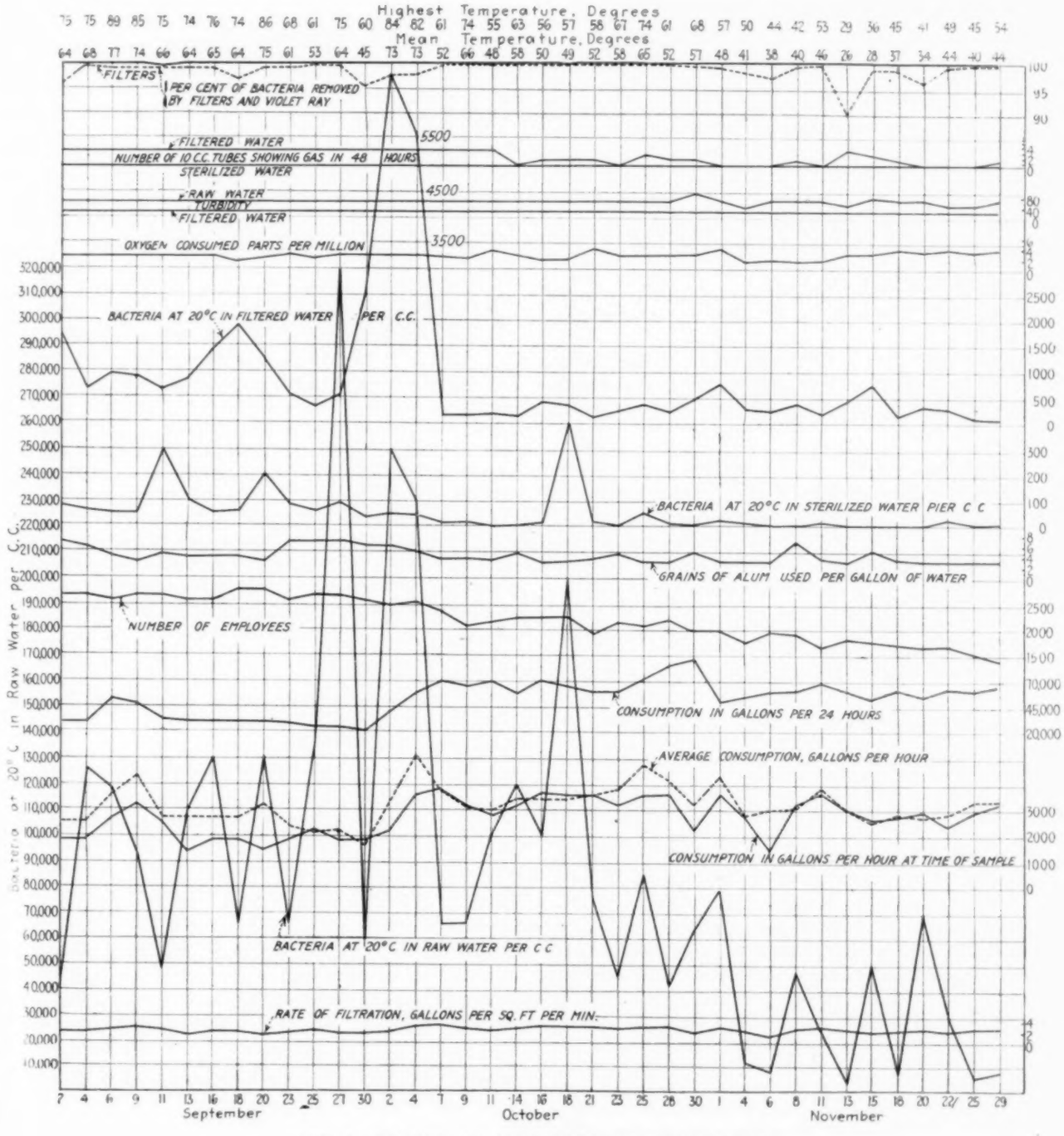

Highest Temperature, Degrees
Mean Temperature, Degrees
FILTERS
PER CENT OF BACTERIA REMOVED BY FILTERS AND VIOLET RAY
FILTERED WATER
NUMBER OF 10 C.C. TUBES SHOWING GAS IN 48 HOURS
STERILIZED WATER
RAW WATER
TURBIDITY
FILTERED WATER
OXYGEN CONSUMED PARTS PER MILLION
BACTERIA AT 20°C IN FILTERED WATER PER C.C.
BACTERIA AT 20°C IN STERILIZED WATER PER C C
GRAINS OF ALUM USED PER GALLON OF WATER
NUMBER OF EMPLOYEES
CONSUMPTION IN GALLONS PER 24 HOURS
AVERAGE CONSUMPTION, GALLONS PER HOUR
CONSUMPTION IN GALLONS PER HOUR AT TIME OF SAMPLE
BACTERIA AT 20°C IN RAW WATER PER C C
RATE OF FILTRATION, GALLONS PER SQ. FT PER MIN.
Bacteria at 20° C in Raw Water per C.C.
September
October
November

FIG. 6. RECORD OF OPERATIONS AT WYANDOTTE

it would be advantageous to keep for the operating end. It was deemed advisable that a continuous record of performance would be an ideal one, for in this manner the operating department would have a clearer conception of what was taking place and the result of any changes that were made from time to time toward the betterment of the system. Accordingly, it was determined that it would be of interest to keep a continuous record of the following points: the bacteria in the raw water; the bacteria in the filtered water; the bacteria in the sterilized water; the turbidity of the raw and filtered water; the per cent of efficiency of bacterial removal in the filters alone; in the combined filters and apparatus; the grains of alum used per gal. of water in the filters; the rate of filtration in gal. per sq.ft. per min.; the hourly and daily consumption of water; the number of men working; the oxygen consumed in the raw water; the presence or absence of pathogenic germs in the treated water. A record of operations involving the above points is shown in Fig. 6. The system as at present installed consists of one 60-in. quartz filter, two 30-in. bone black filters, and two ultra-violet ray sterilizers in series, the normal capacity of which is 3,000 gal. of water per hr. free from pathogenic organisms.

The most important curve of the series is the second one from the top of the sheet reading, "Number of 10 c.c. tubes showing gas in 48 hr." It is this curve that denotes the presence or absence of pathogenic bacteria in the drinking water as same issues from the sterilizers. This curve is to be taken in conjunction with the curve marked, "Bacteria at 20 deg. C. in sterilized water."

You will note that with the excessive contamination with which we had to deal this latter curve denotes the presence of bacteria in numbers from 1 to 400.

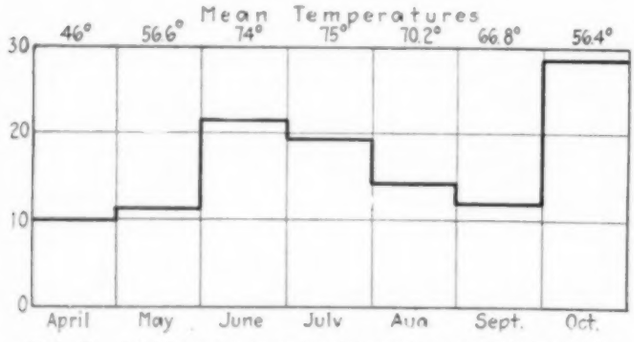


FIG. 7. GAL. OF WATER USED PER MAN PER 24 HR.

Remembering that the spore-forming bacteria are much harder to kill and that the objection to them *per se* is nil, as they are not inimical to one's health, the point then in question is to what family do the bacteria belong whose presence is shown in the curve of sterilized water.

Luckily, the pathogenic bacteria, together with the *B. coli*, are made to reveal their presence by a certain method of treatment. If placed in a tube of standard lactose solution they ferment same with the production of gas. Thus it is a simple matter to simply note the presence or absence of gas in the tube after 48-hr. incubation to determine with reasonable certainty the presence or absence of these objectionable bacteria.

In each case three tubes are planted for the filtered water and three tubes for the sterilized water. You will note that in the majority of analyses the water after passing through the filters showed the presence of *B. coli* in all three of the tubes. The curve for the sterilized water is a straight line zero curve, showing that the violet-ray sterilizer has functioned properly in killing all the *B. coli* germs that were left after passing the filters.

Rates of Consumption of Water

One of the interesting points developed was the excessive use of water per man. Being unable to find any record of the amount of water used per man in a distinct and separate system of drinking fountains, we had to simply fall back on an assumption of how much water might be used during the hottest days of summer and then multiply this by a factor of safety, or more properly speaking, a factor of waste. Fig. 7 shows the amount of water used per man per day for a period of seven months, from April to November. The water meter, being located next to the apparatus, naturally recorded the passage of all water, whether consumed or running to waste through some leak or leaks in the system of underground piping or in the drinking fountains. The sudden increase in the curve for October was unexpected and was due to a break in one of the underground mains, which continued to waste water until located. It was this loss of water that brought the average for the month higher than any other month, even though the number of men employed was considerably reduced.

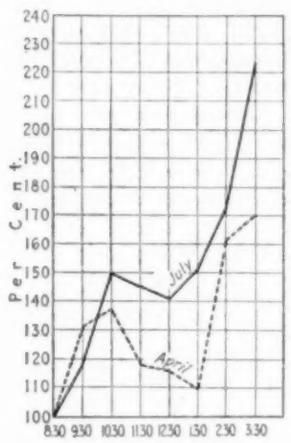


FIG. 8. PERCENTAGE OF WATER USED DURING THE VARIOUS HOURS OF THE DAY DURING THE MONTHS OF APRIL AND JULY

Fig. 8 shows a comparison of the amount of water used during the main working hours of the day. That used between 7:30 and 8:30 was arbitrarily assumed at 100 per cent and the amounts used during the other hours of the day as a percentage of this amount. The curve was first drawn up for July. It shows a very decided and pronounced increase from 1:30 to 3:30, which was quitting time. In order to ascertain if this same tendency for a drink during the last two hours of

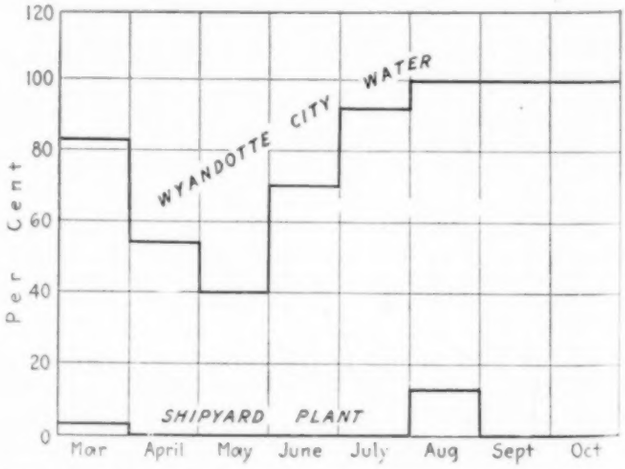


FIG. 9. PERCENTAGE OF TEST TUBES SHOWING PRESENCE OF PATHOGENIC BACTERIA

work existed during the cooler months, the month of April was picked out and the quantities for this curve were derived. From a study of the curves it would lead one to believe that the operator in the plant that recorded the readings had as good, or perhaps a better, survey of the amount of activity going on than the superintendent on the ground.

According to the old adage that "the proof of the pudding is in the eating," Fig. 9 is the proof that the system adopted provided a drinking water that was superior in all respects to that furnished by the city, and that our hoped-for results had been at least fairly well accomplished. Analyzing this record, with the inclusion of the November record, which was also zero, we find that during the nine months period on only three days was there any question as to the absence of pathogenic germs in the drinking water. On two days in August we fell down on our record for the reason that there was a sudden high increase in the bacterial count

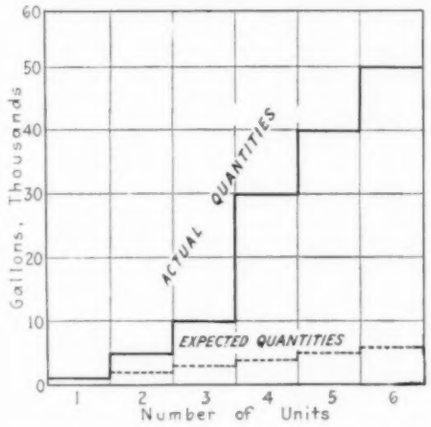


FIG. 10. GAL. OF WATER PER HR. PER UNIT OF VIOLET RAY APPARATUS

in the raw water, and at the same time the system was operating at 50 per cent overload, and one day in March when the capacity of the system was being increased and before all proper adjustments had been made.

An interesting development of the violet-ray apparatus is that the amount of water that can be treated does not vary in arithmetical progression with the number of units used. If the destruction of pathogenic germs depends upon the length of time of exposure to a light source, it would be only natural to assume that if one unit treated 1,000 gal. of water per hr. at a stated velocity through the apparatus should the velocity be increased by two, it would be necessary to put a second unit in series with the first so that the total length of time of exposure in the two would equal the one unit at half the velocity. Repeated tests, however, have demonstrated that such is not the case.

In the new units that are being developed it has been found that the amounts of water that can be treated by six units in series is as shown in Fig. 10. Beyond six units in series there is no further effect in the reduction of pathogenic organisms.

Recent tests have developed the unique and interesting fact that water treated with ultra-violet rays has a residual effect. If to a sample of water that has been sterilized fresh bacteria are added it was found that in an hour's time 90 per cent of these added bacteria had succumbed. What was in the water that killed them is at present open for study and research.

Belgian Industries One Year After the Armistice

THE Belgian Ministère de l'industrie, du Travail, et du Ravitaillement has just completed a survey of the status of unemployment and of the extent to which various Belgian industries had recovered in December, 1919. The investigation was conducted jointly by the Administration of Mines and the Labor Inspection Service, the former considering conditions in the extractive and metallurgical industries, and the remaining industries being covered by the labor inspectors, whose inquiry was extended to all establishments employing more than twenty workmen in 1914. Comparisons are made on the basis of production and employment on corresponding days in December, 1913, and December, 1919. It is obvious that comparisons made on the basis of one day's output may sometimes be misleading.

At first glance the results of the investigation are discouraging from the standpoint of comparative labor output. From the standpoint of actual production in comparison with pre-war output, they indicate, however, the remarkable industrial revival already commented upon by all recent visitors to Belgium. The effect of the general introduction of the 8-hr. day and of the large amount of work necessary to restore plants and mechanical equipment in some industries is shown by the following figures:

In December, 1919, the coal mines produced 94 per cent of the 1913 output, although labor employed amounted to 104 per cent of the pre-war figure. Coking plants were producing 37 per cent of the pre-war output while employing 53 per cent of their 1913 personnel. Plants for making briquets for the railways and other industrial uses attained 98 per cent of the pre-war production, with an increase of 9 per cent over the pre-war labor force.

The poor showing made by the iron and steel industry is no doubt attributable to the unusually severe damage suffered by such plants and the consequent necessity of employing large numbers in rebuilding and repairing foundries and mills and installing new machinery or stolen equipment recovered from Germany. With 60 per cent of the pre-war personnel, the iron foundries and steel mills produced in December only 34 per cent of their pre-war output, but this was a considerable increase over preceding months.

Still more serious is the condition of the zinc foundries, which in December were turning out 18 per cent of the pre-war production with 54 per cent of the labor employed in 1913. Special difficulties in obtaining ores and other raw materials are probably responsible for this large proportion of labor to output. The production of lead was only 9 per cent of the 1913 total, while copper production was about 28 per cent. In the quarries, an important and very diversified Belgian industry, production was slightly less than 50 per cent with a personnel of about 54 per cent.

According to the finding of the Administration of Mines, 115 establishments, including coal mines, coke and metallurgical plants, and quarries of various kinds, gave war destruction as the chief reason for subnormal production, eighty plants specifying lack of transportation facilities, fifty-two lack of adequate coal, forty-nine labor shortage, thirty reduction of working day, twenty-three lack of raw materials other than fuel, and thirty-three (all quarries) lack of orders.

Legal Notes

By Wellington Gustin

Pointers to Inventors and Users of Secret Processes

Some of the distinctions in the remedies one may have in courts of equity as against courts of law are given in a case from the Court of Chancery of Delaware involving the claims of an inventor who discovered a new process for making powder. (O'Neil vs. E. I. du Pont de Nemours & Co., 106 A., 50.) In his bill which states his cause of action the complainant alleges that in 1909 and 1910, while employed by the government of Brazil, he discovered an improved process for the manufacture of propellant explosives. This formula he submitted to one of the directors of a powder corporation for the purpose of selling it to that company. This corporation is alleged to have manufactured and sold great quantities of powder made in accordance with this process, without the knowledge or consent of the inventor. In October, 1915, the defendant corporation purchased all the assets and assumed the liabilities of this powder company, and in December, 1915, the inventor entered its employment.

The inventor further alleges that as soon as he learned of the use made of his process, he made inquiries and on Aug. 9, 1915, the defendant company presented to him applications for patents of his process, with assignments to be executed by him to it of the full and exclusive right to the process and invention. The assignments were made, as the inventor alleges, "with express understanding that your orator would be compensated for the value of the said process and invention, and relying upon the promises and inducements so held out to him, and relying further upon the bonus plan which had been promulgated by the said defendant company and the promises of reward therein contained."

Inventor Alleges Promises Were Fraudulent

Continuing, the inventor alleged that he was later informed by the company that the bonus plan did not apply to him. However, in July, 1918, he received notice that certain benefits under the bonus plan of the company had been granted to him, but these he refused to accept as not being fair or adequate compensation for the assignments. Then, it was alleged, by reason of undue advantage taken by the defendant company of the confidential relations between employer and employee, and of the distressful financial condition at the time the assignments were made, the assignments were secured by the defendant without consideration, and as the result of the fraudulent promises and practices of the defendant company, he had been deprived of the use of the process, and by its use the company made large profits to which he was entitled, and the defendant company was chargeable with the profits it made.

The relief asked for by the inventor were an injunction against the taking of any steps to obtain the patents on the process; for a reassignment of the applications for patents; and for an accounting by the defendant.

To these allegations of the complaint the defendant demurred, raising the question whether his remedy was in court of law or in equity, assuming of course, that the facts claimed gave the inventor a right to enforce compensation from his employer. If he has a full, adequate and complete remedy in a court of law then he has no right to relief in a court of equity, said the Chancellor. In either court he must prove the contract, or facts from which the law will imply a contract, and his damages or compensation for the use of his invention. At law he has power to examine the books of the defendant company as fully as in equity. Indefiniteness in the terms of the agreement, or his inability to prove the making of it, do not entitle him to equitable relief, said the Chancellor. The demand for payment would not create a right in equity, or at law. Neither would the tender of certain benefits as stated have any greater weight in equity than at law if used as evidence of a recognition of a duty to compensate the inventor. And the prayer for an accounting of the profits derived from the use of the process does not of itself give jurisdiction to equity.

Conclusion of the Court

The following are the holdings and conclusion arrived at by the court. Where an inventor disclosed his new process to his employer, relying on promises of compensation if it proved valuable, and the employer without his knowledge used it and made large profits, and also obtained for a nominal consideration an assignment from him of applications for patents, and thereafter tendered him compensation which he deemed insufficient, he has an adequate remedy at law for breach of contract, and therefore cannot maintain a suit in equity for an accounting.

Where an inventor for a nominal consideration assigned his applications for patents to his employer, which in addition agreed to compensate him if the invention proved valuable, but no price for such compensation was fixed, his action is in a court of law in a suit on a quantum meruit. Further, if the employer used the invention and derived a profit through such use, the employee inventor could not maintain a bill in equity for cancellation of the assignment of the application for patents; there being no fraud, actual or constructive, and his remedy being at law for recovery on the agreement to compensate.

Again, said the court, where an inventor disclosed his invention and assigned his application for patents thereon for a nominal consideration to his employer, which agreed to compensate him, failure so to compensate him would not in itself give a right to equitable relief, on the ground of the existence of a confidential relation between the parties. Further, where the employer, in addition to the nominal consideration, agreed to compensate the inventor if the process proved valuable, his employer's mere failure to compensate him under such agreement is not ground for recission of the agreement or cancellation of the assignments of the applications by the inventor, affording relief in a court of equity.

Regarding the inventor's right in his invention before issuance of patent, the Chancellor said he had a property right before the patent is obtained, which right is enforceable in a court, where he has agreed that another may use the invention in consideration that compensation be paid him in case the invention is found valuable.

Allegations of a bill in equity as to fraud must show the subject matter constituting the fraudulent conduct, as distinct from the evidence to prove the subject matter, said the Chancellor; and though a bill in equity characterizes defendant's acts by the expressions "fraud," "fraudulent," "fraudulent conduct and practices," where it avers no substantive facts as to fraud, no case of fraud is made out, so as to bring the case within equitable jurisdiction.

Aluminum Rolling-Mill Practice—IV Slabbing

Design of Rolling Mills and Plant Layout Are Discussed by the Authors, Together With a Detailed Account of All Hot and Cold Slabbing Operations Before Delivery of the Metal to the Finishing Department*

BY ROBERT J. ANDERSON AND MARSHALL B. ANDERSON

MILLS for rolling aluminum have been fairly well standardized as to design, and the essential features have not been changed in recent years. In the design of aluminum rolling mills, it is convenient to couple up a number of mills from one main drive so as to form a train. There is no advantage to be gained in driving the mills separately except in the case of strip mills.

ALUMINUM HOT MILL

An aluminum hot mill is a two-high mill employed mainly for breaking ingots down into slabs. Fig. 1 is a photograph of an aluminum hot mill, taken so as to show the front of the mill, while Fig. 2 is the same mill from the rear. The coupling stand for coupling up additional mills is shown in the foreground of both figures. In Fig. 1, a roughing mill is shown coupled into the system, at the left hand side of the photograph, thus forming part of a roll train. The hot mill illustrated in the photographs is a typical breakdown mill with geared mechanism on top of the mill for raising and lowering the upper roll.

Rolls are made of gray cast iron with a heavily chilled face, and their breakage is a heavy expense item in aluminum rolling. When the rolls become hot, the differential expansion of the gray and white iron, together with the internal strains usually present in a chilled roll, is often sufficient to cause fracture. Rolls fracture more often when the breakdown temperatures are too high or where there is lack of uniformity in the temperatures of successive ingots.

The hot mill shown in the photographs has rolls 28 x 84 in. (0.61 x 2.13 m.) running at the rate of 24 r.p.m. or a peripheral speed of 176 ft. per min. (53.6 m.). The flywheel in the system shown weighed 32 tons, and such a wheel is heavy enough to balance ten finishing mills, five hot mills, or a train of say one hot mill, two roughing mills and six finishing mills.

In the case of an aluminum hot mill, it is convenient to have a dial, shown on top of the mill in Fig. 2, divided into fifty equal parts, numbered consecutively. This dial is geared to the mechanism and motor for raising and lowering the upper roll in such a way that one revolution of the dial corresponds to a lateral movement in the upper roll of 1 in. Hence, fifty numbers equal 1 in., or one number equals 0.02 in. (0.5 mm.). By this arrangement the hot roller can figure his reductions readily. Due to wear in the journals and strain in the mill, the pointer of the dial may get out of alignment with the numbers and the position of the roll, and it is advisable to make adjustments at least daily. When a shift comes on, and before any rolling is performed, the screw boy should run the upper roll down tightly against the lower one; if the dial pointer is not at 50, i.e., zero, proper adjustment should be made.

Front and back floor plates (shown in Figs. 1 and 2) are important parts of breakdown mills, and unless these are of the correct design, much difficulty will be had in rolling. The front plate should be equipped with six small rollers set not more than 2 or 3 in. from the lower roll and if so placed the workmen will be relieved of much lifting. Back floor plates should consist of a heavy rod, set in the grooves from housing to housing; eight cast iron fingers, with small rollers on the end, are placed in a groove in the top of the rod. If a slab becomes stuck to the mill, the fingers will fly back and remove the strain from the back floor plate rod, as the slab goes around on the roll. Then the mill can be shut down and the slab removed. With rigid fingers, a slab stuck as mentioned will push on the fingers and break the back floor plate.

Roughing and finishing mills are similar in their general characteristics, and slabbing is done on a mill similar to a hot mill. Both roughing and finishing mills are of lighter construction than hot mills and slabbing mills because the work performed by the former is not so heavy. The upper roll is raised and lowered by hand, in the case of roughing and finishing mills, by means of a hand wrench on either side; the mechanism is shown in Fig. 1. Geared mechanism with motor drive is not used on these mills because the upper roll is not moved far, either up or down, as is the case with hot mills and slabbing mills. Roughing and finishing mills run at somewhat faster speeds than breakdown mills; for example, rolls in the former mills may run at the rate of 34 r.p.m., or a peripheral speed of 250 ft. (76.2 m.) per min. for 28-in. (0.71-m.) rolls. Roughing and finishing mills are built in various sizes

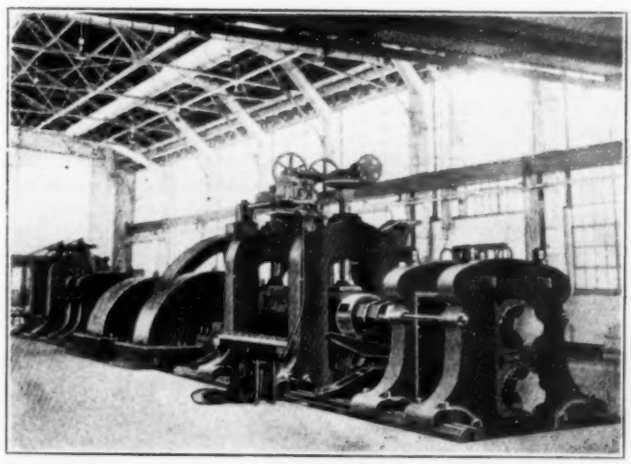


FIG. 1. ALUMINUM HOT MILL, 28-IN. ROLLS, IN TRAIN, FRONT VIEW

*For Parts I, II and III, see CHEM. & MET. ENG., vol. 22, Nos. 11, 12 and 13, March 17, 24 and 31, 1920, pp. 489, 545 and 599.

according to requirements; thus the rolls may be 28 x 60, 28 x 84, and up to 120 in. (0.71 x 3.05 m.).

Strip mills are usually operated as separate units, and this is so largely because of the amount of space required on both sides of a strip mill for handling coils. A typical single-unit strip mill has rolls 20 x 36 in. (0.51 x 0.91 m.), running at 25 r.p.m., or a peripheral speed of 131 ft. (40 m.) per min. Single-unit strip mills are driven by an individual motor, and they have mechanism similar to the hot-mill mechanism for raising and lowering the upper roll. This mechanism may be controlled by hand wheels rather than hand wrenches. A two-high continuous strip mill, with five mills in a row driven by one motor, is used for rolling strip faster than is possible in a single-unit strip mill. The reductions may be so arranged that the mills are set as follows:

Mill	Takes metal, in. thick (1 in. = 25.4 mm.)	Breaks to, in. thick (1 in. = 25.4 mm.)
First	0.375	0.300
Second	0.300	0.225
Third	0.225	0.150
Fourth	0.150	0.090
Fifth	0.090	0.064

A 0.375-in. slab will thus enter the first mill and emerge from the last as finished 14-gage strip, in one operation. The precise details in design of aluminum rolling mills vary with different builders, and the above brief descriptions give only the main points with regard to their construction. Furthermore, the layout for aluminum rolling mills will vary according to the amount of the output, the variety of the output, and other factors.

Layout of a Rolling Mill

In planning the layout of a mill, it is necessary to correlate carefully the capacities of the various mills with the melting and annealing equipment so that the complete mill will not be overbalanced in any department. No mention of the construction of mill buildings will be made other than to say that they should be well lighted, properly heated and ventilated and of modern design. Considering a mill of moderate size which shall have an output of 14,000 to 15,000 lb. (6.3 to 6.8 metric tons) of heavy sheet and 10,000 to 12,000 lb. (4.5 to 5.4 metric tons) of light sheet per day, the necessary equipment will comprise the following: Two 5,000-lb. (2,300-kg.) melting furnaces, one hot mill, two roughing mills, four finishing mills, and a strip mill. An ingot-heating furnace and two annealing furnaces will make up the metal-heating equipment.

Two 5,000-lb. melting furnaces can produce 9,000 lb. (4,100 kg.) of rolling ingots in 8 hr., or 27,000 lb. (12,250 kg.) per day. One five-track ingot-heating furnace will have sufficient capacity for preheating the ingots. A day shift can break down 27,000 lb. of ingots in the hot mill, and the same amount of metal can be cold slabbed on this mill by a night shift. Roughing, finishing and strip rolling performed continuously day and night with the equipment mentioned will turn out 24,000 to 27,000 lb. (11 to 12 metric tons) of finished aluminum sheet per day. In this case, we are assuming that about 33 per cent of the output consists of metal lighter than 20-gage and 66 per cent heavier, since heavy sheet can be rolled faster than light gage—for example, 14-gage cold-rolled aluminum sheet can be turned out about 1.5 times as fast as 20-gage, while the disproportion is larger with wider variations in gage.

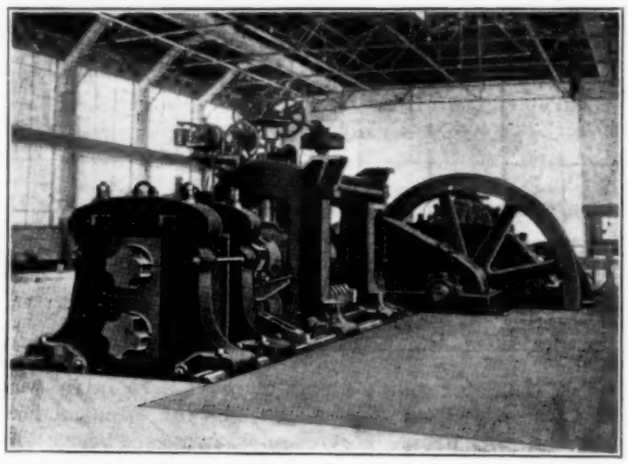


FIG. 2. ALUMINUM HOT MILL, 28-IN. ROLLS, IN TRAIN, REAR VIEW

With a mill as outlined, the hot mill, two roughing mills and four finishing mills would be run on one roll train with direct motor drive; the strip mill would be operated as a separate unit. In breaking ingots down into slabs, it is advisable to employ two hot mills in a plant of double capacity than the one outlined. With two hot mills, a crew of four men (one roller and three catchers) would be employed. After rolling metal on one mill for 30 min., that mill would be cooled, and the crew would move over to the other mill; the catchers would work on shifts, one catcher resting every 30 min. With one hot mill, ingots are being rolled only about half the working time because of the necessity for cooling the rolls at intervals.

A well-designed mill of the capacity mentioned should have at least five shears: A circle shear, a gang shear, a slab shear, and a large and a small shear for finishing and re-squaring. Slabs and light sheets should not be cut on the same shear. In addition to the equipment already mentioned, a mill of moderate size should include a flatter and a strip cleaner. The latter should be placed in a separate building if gasoline is used for cleaning. A suitable overhead electric crane, with say 5- and 20-ton hoists, should run the length of the main mill building.

Hot-Mill Crew

A hot-mill crew consists of the following men: An ingot pusher, a trucker, a roller, two catchers, and a screw boy. Strictly speaking, the ingot pusher should be classed as an ingot-furnace operative, and the trucker as partly an ingot-furnace and partly as a hot-mill operative. These distinctions are, however, somewhat academic in discussing rolling-mill practice from the metallurgical viewpoint, but they do become important in cost finding.

These operatives perform the following work: The ingot pusher stacks up cold ingots at the charging end of the ingot-heating furnace and operates the pushing ram so as to keep pace with the withdrawal of hot ingots from the front of the furnace. The trucker withdraws hot ingots from the front of the furnace by means of tongs, trucks ingots to the hot mill, and places them in position on the hot-mill floor plate for rolling. The roller is in charge of the work and puts the metal through the rolls from his side of the mill. The catchers, working on the opposite side of the mill from the roller, catch the rolled metal with tongs after each

pass, return it over the upper roll of the mill to the roller, and, after the final pass, place the resultant slab in a pile adjacent to the mill. The screw boy controls the reduction of the ingot with each pass by operating the electrically-driven upper roll through a hand controller.

Under good conditions, such a crew can roll, on an average, 275 4 x 12 x 14 in. (10 x 30 x 35 cm.) ingots in 10 hr. to 38 x 86 x 0.25 in. (96 x 218 x 0.6 cm.) slabs, the number being dependent upon the size of the ingots and the required slabs.

Rolling Temperatures

Allowing for the cooling of a hot ingot during the elapsed time between its withdrawal from the furnace and the first pass, the metal is rolled at a temperature of from 410 to 435 deg. C., although these figures are simply estimates. Some actual temperature measurements have been made by the writers in the case of ingots rolled directly from the molds. These measurements showed that the temperatures of succeeding ingots varied considerably, due to different pouring and mold temperatures and variations in time elapsed after pouring and before rolling. Furthermore, the interior of an ingot may be at a different temperature than the exterior; it may be higher than the exterior in ingots rolled directly from the molds, and lower in ingots preheated for too short a time, or cooled for too long a time after heating, prior to rolling. In any event, there is doubtless considerable variation in temperature not only between individual ingots but also in different parts of the same ingot. Fire-cracked slabs have been mentioned previously as being the result of too high breakdown temperatures. Fire cracks can be largely eliminated in the subsequent rolling if there is sufficient thickness after roughing so that the cracks can be eliminated on finishing.

Rolling Practice

Ordinarily, an aluminum ingot is rolled by giving it two or three passes so that the ingot is elongated to a length sufficient to make the desired width of the slab, whereupon this resultant thick slab is turned at right angles to the original direction of rolling and cross-rolled to the desired thickness. Provided an ingot of the correct size has been rolled, the resultant slab will be of the required dimensions. In breaking down, the first pass should be light so that the roller can obtain an idea of the condition of the metal; if too hot, the ingot will probably break or crack; if too cold, that fact will be noticed in the mill. If the required sheet is not too wide, say under 60 in. (1.5 m.), and 4 x 12 x 17 in. (10 x 30 x 43 cm.) ingots are being broken down, it is good practice to roll to the width with a heavy reduction on the second pass; on the other hand, if the required sheet is to be wider than 60 in., it is better to take only a fairly heavy second pass and roll to width on the third or fourth pass. In hot rolling ingots for wide sheets, it is better to make the passes reasonably light, otherwise the slab is likely to become distorted out of square and thus cause high scrap losses at the hot mill. Where the length is extremely disproportionate, it is difficult to keep the slabs even approximately square at the corners. Broadly speaking, the heaviest reduction should take place on the second pass, but the practice is necessarily variable.

Partial curling up or sticking of slabs to the hot-mill rolls is due to lack of kerosene, which should be liberally sprayed on the rolls before rolling each ingot. Kerosene is much better than so-called "solutions," made by mixing lubricating oils in water; it is often difficult to start an ingot when such solutions are used, and at times, after the ingot does start into the rolls, it will turn suddenly at right angles and roll on the wrong dimension. If an ingot curls up even though kerosene is used, it often helps if a little cup grease is rubbed on the surface; on the succeeding pass the slab will then straighten out.

Supposing now for explanatory purposes, 16-gage (1.29-mm.) cold-rolled sheet is desired which shall, when finished, cut without an undue amount of scrap to 36 x 144 in. (0.91 x 3.66 m.). In order to obtain the required slab to make such a sheet, an ingot whose dimensions are 4 x 12 x 17 in. is first given a light pass in the hot mill—the 4 x 12 in. side entering the angle of nip on the rolls—and then a heavy pass (reducing about 1 in.) in the same direction and then a light pass so that the resultant thick slab after these three passes has approximate dimensions of 1.8 x 12 x 38 in. (4.6 x 30 x 97 cm.). The slab is then turned 90 deg. with the first direction of rolling and cross-rolled to ¼ in. (6.3 mm.) thick, when it will have approximate dimensions of 0.25 x 85.9 x 38 in. (0.63 x 218 x 97 cm.). The first three passes are calculated to produce a length of 38 in. (97 cm.), and when this thick slab is turned for cross rolling this 38-in. length becomes the width

TABLE XV. SCALE FOR HOT ROLLING 3.5 x 12 x 24-INCH INGOTS TO VARIOUS WIDTHS AND THICKNESSES

Width in.	Dial pointer stands at first pass	second pass	third pass	fourth pass	fifth pass	sixth pass	seventh pass	Thickness, in.
15	40	**20**	45	15	29	..	..	0.500
16	40	**15**	45	12	29	..	..	0.500
17	50	**30**	12	29	..	..	..	0.500
18	50	**34**	12	29	..	..	..	0.500
19	50	**38**	12	29	..	..	..	0.500
20	40	**20**	**34**	12	30	..	..	0.500
21	40	**20**	**40**	12	30	..	..	0.500
22	40	**20**	41	12	30	..	..	0.500
23	40	**20**	**42**	12	30	..	..	0.500
24	40	**20**	47	12	30	..	..	0.500
25	40	**20**	**50**	13	30	..	..	0.500
26	40	**22**	**40**	**1**	24	36	..	0.375
27	40	**22**	**40**	**3**	24	36	..	0.375
28	40	**22**	**40**	**5**	24	36	..	0.375
29	40	**24**	**40**	**7**	24	36	..	0.375
30	40	**24**	**40**	**10**	24	36	..	0.375
31	40	**24**	**42**	**11**	24	36	..	0.375
32	40	**24**	**42**	**12**	24	36	..	0.375
33	40	**24**	**44**	**14**	24	36	..	0.375
34	40	**24**	**45**	**15**	24	36	41	0.250
35	40	**24**	**45**	**16**	24	36	41	0.250
36	40	24	50	18	24	36	41	0.250
37	42	24	50	18	24	36	41	0.250
38	42	24	50	18	24	36	41	0.250
39	50	24	50	18	24	36	42	0.250
40	**2**	24	50	18	24	36	42	0.250
41	**3**	24	50	18	24	36	42	0.250
42	**40**	24	50	18	24	36	42	0.250
43	**40**	**13**	45	18	24	37	42	0.250
44	**40**	**14**	45	18	24	37	42	0.250
45	**40**	**16**	45	18	24	37	42	0.250
46	**40**	**18**	45	18	24	37	42	0.250
47	**40**	**19**	45	18	24	37	42	0.250
48	**50**	**20**	48	18	30	36	42	0.250

Ingot is cross-rolled on the passes where the dial numbers are printed in bold face type (see text).
Many variations are possible in breaking down ingots.
1 in. = 2.54 cm. 1 dial division = 0.55 mm.

The exact reductions which are given to ingots may vary considerably for the reason that there are numerous combinations possible. An empirical scale for hot rolling is given in Table XV for breaking 3.5 x 12 x 24 in. (9 x 30 x 61 cm.) ingots to various widths and thicknesses, the length being allowed to run. The dial numbers refer to the numbers at which the pointer should stand after each set of the rolls, and those numbers in bold-face type indicate that the ingot should be turned at right angles (cross-rolled) on the pass. In each instance, the ingot is normally rolled by putting

the 3.5 x 24 in. side through the rolls on the first pass, so that cross-rolling may be interpreted as rolling at right angles to this dimension, i.e., on the 3.5 x 12-in. side. Where bold-face figures appear for the first pass, the 3.5 x 12 in. side enters the rolls; before each pass indicated by a bold-face number, the ingot will be turned.

After each ingot is broken down, the resultant slab is piled in a pile adjacent to the hot mill, and all lots are kept separate. After a track of ingots has been rolled, the rolls are cooled with a water spray from a perforated pipe for about 15 min. During this time the rolls are revolving. The water cooling should not be continued too long, as otherwise a coating may form on the rolls; this coating will then come off when the next ingot is rolled, and possibly scrap the slab.

Cold Slabbing

All aluminum slabs made on the hot mill, except those intended for strip rolling and sheets to finish 0.101 in. (10-gage, 2.59-mm.) or heavier, are slabbed cold on a slabbing mill. In a small plant, it is often necessary to slab cold on the hot mill at night, and run the hot mill on ingots only during the day. Whether that is done or a separate mill is employed does not alter the principles involved, since slabbing mills are the same as hot mills to all intents and purposes, so far as construction goes. Slabbing may also be done on a roughing mill.

On a slabbing mill there will be one roller, one helper, and two catchers. The roller and his helper work in front of the mill and the two catchers behind the mill. In slabbing, the roller and helper push the slab through the mill, and the two catchers receive it and pass it back over the top roll. In the manufacture of sheets, aluminum is handled with tongs only at the hot mill; during slabbing, roughing and finishing it is manipulated by hand.

The majority of hot-mill slabs are slabbed cold to one-half the original hot-roll thickness; for example, 0.25-in. slabs are reduced to 0.125 in., 0.30-in. slabs to 0.15 in., and so on. The exceptions to this rule have been stated previously in connection with the examples for calculations, and the slabbing thicknesses for sheets of various gages and sizes are given in Table IX.* The desired object is accomplished by giving the slab about five to fifteen passes with two or three sets of the rolls. Slabbing is a continuous operation, and there is no "spelling." Normal production will be about 2,000 lb. (910 kg.) of metal per hr. Kerosene should be swabbed on the rolls and metal during the slabbing operation in order to prevent the metal from sticking.

Slab Shearing

After cold slabbing, all slabs going to make sheet aluminum are sheared on both ends and cut to such lengths as will make (with certain exceptions to be noted later) the required finished sheets. Slabs are cut into from two to twenty-five pieces. Where only one large sheet is to be made from a slab, a hot-mill slab is sent directly to the finishing mill without cold slabbing, shearing or roughing. All slabs destined for the strip mill are sheared on both ends, and the edges are trimmed to remove any cracked metal; shearing the edges helps to prevent further cracking during strip rolling, and provides for straight edges. In the case of strip-roll slabs, two or four pieces are cut from the hot-mill slab.

Slab shearing follows cold slabbing in the mill scheme with the exceptions already described. The amount of scrap made by slab shearing averages from 10 to 12 per cent of the hot-mill production, but will vary with conditions. With correct shearing, it should be close to 10 per cent. Slab shearing is performed upon large power shears of well-known types, and the slabs should be sheared as fast as they are rolled on the slabbing mill. The slab shear is operated by a shearman and two helpers. After shearing, the slabs are stacked near the roughing mill, if they are to be roughed; some slabs are sheared and sent directly to the finishing mill; in either case, the sheared slabs should be piled near the proper mills.

In the example for calculating sheets, it was pointed out that very large shearing losses may arise in the manufacture of aluminum sheets because of miscalculations with regard to the size of ingots rolled. If the right size ingots are rolled, the slab-shear scrap should not exceed 10.1 per cent of the hot-mill output. There is 10 per cent allowed for rounded ends and other irregularities in shape, and 0.10 per cent is added because most of the calculations cannot come out exactly. An example is given in the following: In calculating an order for 16-gage sheets, 40 x 144 in., the figures are:

0.150 ÷ 0.050 = 3
160 ÷ 3 = 53+
106 ÷ 53 = 2, the number of cuts to a slab. This results in practically exact figures. Comparing this with an order for 20-gage sheets, 25 x 60 inches, the figures are:
0.125 ÷ 0.031 = 4
80 ÷ 4 = 20
177 ÷ 20 = 8 + 17, or there will be eight cuts to a slab and 17 in. of scrap.

The 17-in. scrap end is weighed with the slab-shear scrap, and 0.10 per cent allowed as an average will provide for such cuts. Excessive slab-shear scrap is due to wrong calculating, to wrong shearing by the shearman, and to poor breakdown practice at the hot mill.

(Part V, the last of the series on Aluminum Rolling-Mill Practice, dealing with finishing operations, will be published in our next issue.)

*See Chem. & Met. Eng., vol. 22, No. 13, March 31, 1920, p. 601.

Imports and Exports of Chemicals

Imports and exports of certain chemicals, as reported by the Bureau of Foreign and Domestic Commerce, for January, 1920, and the figures for January, 1919, as finally revised, are as follows:

EXPORTS OF CHEMICALS

	Jan., 1919 Lb.	Jan., 1920 Lb.
Acids:		
Carbolic	229,497	440,832
Nitric	49,411	13,270
Picric	22	5,567
Sulphuric	1,067,763	1,768,749
Calcium acetate	55,765	3,632,782
Calcium carbide	2,286,388	736,959
Calcium chloride	1,579,847	2,983,782
Copper sulphate	2,847,199	346,947
Potassium chlorate	410,979	409,154
Soda:		
Caustic	17,402,125	14,180,004
Sal soda	1,453,780	552,193
Soda ash	15,034,056	5,676,972
Sodium silicate	2,008,597	1,771,143
	Value	Value
Dyes and dyestuffs	$2,318,061	$1,449,153

IMPORTS OF CHEMICALS

	Jan., 1919 Lb.	Jan., 1920 Lb.
Calcium acetate and chloride (crude), carbide and nitrate	11,260,828	5,684,135
Dyes	216,952	539,144
Gums	4,694,962	12,328,990
Potassium carbonate, including crude or black salts	120,953	1,289,938

Methods for Analytical Control of Electrolytic Zinc Production

A Description of the Methods Used at the Electrolytic Zinc Plant Laboratory of the Judge Mining & Smelting Co., Park City, Utah, for the Analysis of Leach and Electrolyte Solutions, Concentrates, Calcines and Leach Residues, Zinc Dust Precipitate and Anode Scale From Cells

By H. F. BRADLEY

IT IS not the purpose of this paper to describe analytical methods for all elements likely to be determined in electrolytic zinc work, but to present a few methods which have been tested and found especially suited to the materials produced in the process outlined below. These methods are in use at the electrolytic zinc plant laboratory of the Judge Mining & Smelting Co. No special originality is claimed, except possibly in suitably combining and modifying standard procedures.

The materials to which the methods apply are produced in the following process:

Concentrates consisting chiefly of zinc blende and pyrite are roasted to convert the zinc to forms soluble in sulphuric acid. The calcine is agitated with a slight excess of dilute H_2SO_4, and the excess acid neutralized with $CaCO_3$ or $Ca(OH)_2$. After settling and filtering, the solution is purified by agitation with zinc dust. The resulting pure electrolyte is electrolyzed with lead anodes and aluminum cathodes, the "cell tail" solution being used again as leach liquor.

Analysis of Leach and Electrolyte Solutions

Leach Solution

The solution used has been neutralized with lime but not purified by agitation with zinc dust.

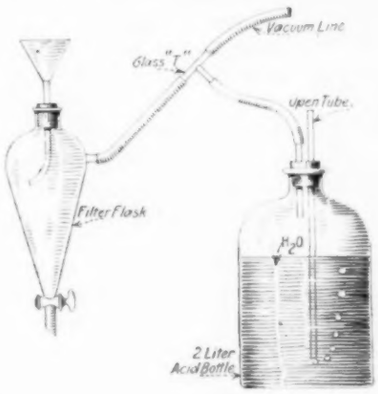
Copper. With pipette take 25 c.c. of solution, add 5 c.c. 50 per cent acetic acid, a little sodium or ammonium phosphate solution to precipitate any iron present, then 10 c.c. of 25 per cent solution of NaI. Titrate as usual with "hypo" (1 c.c. = 0.0025 g. Cu).

This method gives results very slightly higher than the precipitation as sulphide and subsequent titration with "hypo." In this solution, the As and Sb are in the higher oxidized condition, and do not interfere.

Cadmium. Measure a convenient amount of solution (depending on the cadmium content), say 100 to 200 c.c., add 15 c.c. H_2SO_4 for each 100 c.c. taken; then add slowly, with stirring, enough Na_2S (10 per cent solution of crystals) to precipitate the copper. Boil about 2 min., test with a drop of Na_2S, and if the copper is completely precipitated, filter hot, washing with hot water. Any CdS precipitated by the Na_2S dissolves again on boiling with the above strength of H_2SO_4 (27 per cent).

Cool the filtrate, and add 15 c.c. strong NH_4OH for each 15 c.c. H_2SO_4 originally added, stirring the solution during the addition. Cool again, dilute to twice the original volume of solution taken, and pass in H_2S 30 min. or more. The dilution and treatment with NH_4OH has reduced the acid strength to about 9 per cent, which is suitable for the precipitation of CdS. (It is usually necessary to start the precipitation by adding a few drops of NH_4OH after passing the gas 5 minutes).

Let the precipitate settle 20 min., and filter by suction on fine papers (such as Munktell's Swedish No. 0), used double with filter cone. A Shaw filter flask,* pear-shaped, with stopcock at the bottom, will be found convenient for suction filtering. A simple vacuum regulator, to prevent breaking the paper, is shown in the accompanying figure. Wash the CdS once with water, then dissolve it in a small volume of hot 1:1 HCl, opening the inner fold of the paper to expose all the precipitate, and finally washing four times with hot water. To the solution add methyl orange, then carefully add NH_4OH until the neutral point is just passed, then add 10 c.c. trichloracetic acid solution (40 per cent). Cool, dilute to 100 c.c., and repeat the H_2S precipitation, filtering and washing five times with Na_2SO_4 solution (about 15 per cent of anhydrous salt). If washed with water, CdS is likely to run through the filter after two or three washings.



Tear the filter into several pieces and place in the original beaker, which now contains 60 to 80 c.c. of cold 1:1 HCl. Add starch and titrate immediately with iodine (2.35 g. per liter) to a distinct blue color, which remains at least 30 sec. while the solution is stirred. The sulphur formed in the reaction causes a pale blue color which must not be confused with the true end-point. Whether or not the true end-point has been reached can be determined by adding more iodine and noting whether the color becomes permanently deeper. 1 c.c. iodine = 0.0010 g. Cd. Standardize the iodine against standard "hypo" (Cu $\times$ 0.884 = Cd).

If preferred, an excess of iodine can be added, the solution stirred for 2 or 3 min., then titrated back with "hypo" (see references 1 and 2). This method checks very closely with the gravimetric method in which the CdS is changed to and weighed as $CdSO_4$.

Solutions containing less than 0.05 g. cadmium per liter should be analyzed by the method given under "Pure Electrolyte." When very low concentrations of cadmium are precipitated with H_2S in acid solution, the results are usually too low by a considerable amount.

*Sold by Eimer & Amend, New York, N. Y.

Antimony. (References 3 and 4.) To 250 or 500 c.c. of solution add 10 per cent by weight of H_2SO_4, heat to boiling, and pass in H_2S about 60 min. Let the precipitate settle a few minutes, and filter on a Büchner funnel, washing five or six times with warm 5 per cent H_2SO_4 to which a little Na_2S has been added, then once with water. Boil the paper and sulphides with 50 c.c. of Na_2S (5 per cent solution of crystals), filter and wash with small volumes of hot water. Treat the filtrate for Sb exactly as in "Pure Electrolyte," below, from the point where $NaClO_3$ is added, etc.

Total Iron. Rapid method. (Reference 5.) To about 300 c.c. of neutral filtered solution add *two drops only* of H_2SO_4, then add $KMnO_4$ from a burette to a *faint* pink color. With pipette take 5 c.c. of this oxidized solution and place in a vial or colorimetric tube of clear glass. Add 2 c.c. of conc. salicylic acid (2 g. per liter), dilute to 25 c.c., mix and compare with standards. If the color is too strong for a comparison, dilute the oxidized solution to two, three or five volumes and repeat the color test, taking the dilution into account when calculating the Fe.

For Acid Solution. Take 20 c.c. of solution and titrate the acid with Na_2CO_3 and methyl orange indicator. Now titrate another 20 c.c. *without* indicator, stopping the titration a little short of the previous reading, so that the solution contains about 0.5 g. H_2SO_4 per liter. Dilute to 40, 60 or 100 c.c. and treat with $KMnO_4$ and salicylic acid as above.

Preparation of Color Standards for Iron. Dissolve 0.249 g. $FeSO_4$ crystals (purified by alcohol) in distilled water, add six drops of H_2SO_4, add $KMnO_4$ from a burette to a faint pink end-point, and dilute to 1,000 c.c. This solution contains 0.050 g. Fe per liter, and can be used straight or diluted to make standards of different values, measured amounts being treated with salicylic acid as above. Standards must be freshly prepared every three or four weeks.

For the determination of Zn, Mn, CaO and MgO, see "Pure Electrolyte," below.

Pure Electrolyte

Traces of impurities remaining in the electrolyte after agitation with zinc dust to displace ions electronegative to Zn are determined as follows:

Antimony and Copper. (Distilled water and pure reagents must be used throughout.) With a graduate measure 1,000 c.c. of solution, add 6 or 7 per cent by weight of H_2SO_4, then add slowly, with stirring, 30 to 50 c.c. of Na_2S (3 per cent solution of crystals; this must be free from chlorides if copper is to be determined). Heat to boiling and boil 1 or 2 min. Let the precipitate settle about 30 min., add a little more Na_2S, and filter by suction on Büchner funnel (10 cm.). (Whatman No. 30 papers, used double, are the best for this purpose.)

Wash four times with dilute H_2SO_4 to which a little Na_2S has been added, and once with water. Continue the vacuum about 1 min. after washing. Fold the paper as usual and place in ordinary funnel, opening the inner fold to expose all of the precipitate; wipe out sulphides adhering to the Büchner funnel and add to the main precipitate.

Now wash the paper with 30 c.c. of hot 3 per cent Na_2S, passing first part of filtrate through again (Whatman No. 30 papers filter rapidly at this point). Wash twice with small volumes of hot water.

To the filtrate add about 0.7 g. $NaClO_3$, heat nearly to boiling, add 15 to 20 c.c. of strong HCl, and boil off most of the chlorine. Cool 1 or 2 min., add 3 c.c. of freshly made 10 per cent Na_2SO_3, and boil a few minutes. (A sheet of asbestos paper under the beaker will prevent bumping.) Cool again about 2 min. and repeat the above treatment with Na_2SO_3 twice more to insure complete reduction of Sb. Add about 0.3 g. tartaric acid and boil down to about 25 c.c. to remove SO_2 and As.

Cool, add a piece of litmus paper, carefully neutralized with NH_4OH, make slightly acid with HCl, and cool again. Add starch, dilute to 100 c.c., add an excess of $HNaCO_3$ or HNH_4CO_3, and titrate immediately to a distinct blue end-point, using the same iodine as in titrating Cd. (See "Leach Solution," above.) The end-point is much sharper in the presence of tartrates than in their absence. One c.c. iodine = about 0.0011 g. Sb (Cu × 0.945 = Sb).

A synthetic solution resembling our electrolyte was made up from spelter, c.p. H_2SO_4, $CaCO_3$, distilled water and other materials known to be practically free from Sb. Various amounts of Sb (as tartar emetic) were added to 1,000 c.c. portions of this solution and the assays carried through exactly as above, with the following results:

Sb Added, Grams	Sb Found, Grams	Sb Added, Grams	Sb Found, Grams
None	0.0003	0.0020	0.0020
None	0.0004	0.0030	0.0029
0.0010	0.0012	0.0040	0.0040
0.0010	0.0011		

The "blank" appears to be practically compensated by some other factor, probably the small amount of Sb_2S_3 remaining in solution.

Copper. After washing with Na_2S, the filter paper still contains the CuS. Pour upon it a few drops of neutral zinc nitrate solution (made by adding a slight excess of ZnO to 1:3 HNO_3; both this solution and the Na_2S used above must be free from chlorides). Place the paper on a scorifier and burn in a muffle at a red heat. The zinc nitrate changes to ZnO and effects the complete oxidation of the CuS to CuO, etc.; any chlorides present will cause loss of $CuCl_2$ by volatilization.

Dissolve the ZnO and CuO in not more than 1 c.c. of 1:2 HCl (warming for a few seconds may be necessary). Add 5 per cent KOH until a permanent white precipitate forms; dissolve the precipitate with an excess of acetic acid, keeping the volume as small as possible; add a few drops of sodium or ammonium phosphate solution to precipitate traces of iron, then about 1.5 g. solid NaI and a little starch. Titrate with weak "hypo" (5 or 10 g. crystals per liter).

The above treatment with zinc nitrate, etc., making unnecessary the usual evaporation with HNO_3, can be applied to as much as 0.020 g. of Cu, possibly more, if the CuS has been precipitated in a fine granular condition. The use of phosphate for Fe was noted in *Chem. News*, vol. 118, pp. 193-4 (R. H. Deakin).

Cadmium. (Use distilled water throughout). To 500 c.c. of solution add 50 g. NH_4Cl, heat to about 60 deg. C., add NH_4OH gradually until zinc hydrate dissolves, then about 15 c.c. excess. Dilute to about 800 c.c., and add slowly, with stirring, 20 c.c. of Na_2S (1 per cent solution of crystals). Heat to boiling and boil about 30 sec.

Let the precipitate settle about 40 min. and filter on a Büchner funnel, using fine double papers (Munktell's Swedish No. 0). Wash several times with warm 1:6 NH_4OH, to remove soluble zinc. Continue the vacuum 1 min. after washing.

Tear the paper into several pieces and place in a 250 c.c. beaker, wiping out any sulphides adhering to the

Büchner funnel. Add 30 c.c. 25 per cent H_2SO_4, boil 2 or 3 min. and filter hot, by suction, washing four times with water.

The filtrate contains Cd and some Zn. Add methyl orange, just neutralize with NH_4OH, add 10 c.c. trichloracetic acid (40 per cent), and determine Cd by two precipitations with H_2S and titration exactly as in "Leach Solution," above. The above method was derived from a method of spelter analysis formerly used by the Anaconda Copper Mining Co.

Zinc. For fairly accurate work, measure 5 c.c. of solution with pipette, add a few g. NH_4Cl, 0.5 to 1 g. ammonium persulphate, dilute to 100 c.c., add 15 c.c. NH_4OH, and boil 6 to 8 min. Filter off Mn and Fe hydrates, washing with dilute NH_4OH. To the filtrate add $CuSO_4$ solution to give a distinct blue color, acidify with 6 to 8 c.c. excess HCl, and add 5 c.c. of Na_2S (20 per cent solution of crystals) to precipitate Cu. Heat not above 75-80 deg. C., and titrate as usual with ferrocyanide.

The $CuSO_4$ acts as a better indicator than methyl orange, and the presence of CuS appears to give a less deceptive end-point than when Cu is absent. But the end-point will often be very deceptive if the solution has been heated to boiling before titrating.

For very accurate work, some standard gravimetric method is preferable.

Manganese. Pipette 20 c.c. of solution into a 100 c.c. measuring flask (calibrated against the pipette), dilute to the mark with distilled water, transfer the beaker, and mix well. If the Mn in the original solution is 0.4 g. per liter or less, take an aliquot of 20 c.c.; if more than 0.4, take 10 c.c., etc. Place the aliquot in a 150 c.c. beaker containing 0.020-0.023 g. $AgNO_3$ and 4 or 5 c.c. HNO_3.

Dilute to 30 c.c., cover, and heat to incipient boiling. Add about 1 g. ammonium persulphate and heat gently (just below boiling) for 1 min. after the pink color appears. Cool to room temperature, dilute to 100 c.c., and add 3 c.c. of NaCl (5 g. per liter). Titrate with sodium arsenic until the pink color just disappears and only the white of the AgCl is visible.

Sodium Arsenite Solution. Dissolve 0.675 g. As_2O_3 in hot distilled water containing 2 g. Na_2CO_3, and dilute to 1,000 c.c. (1 c.c. = 0.0002 g. Mn). Theoretically, about 0.908 g. of As_2O_3 is required, but the reaction actually does not proceed according to the usual equation. Apparently, this is not realized by some writers giving this method.

Standardize the arsenite as follows: From a burette run 10 c.c. $KMnO_4$ (0.574 g. per liter) into a small beaker containing the $AgNO_3$ and *colorless* HNO_3. Dilute to 100 c.c., add the NaCl and titrate as above. Run at least three standards and take the mean. If 1 c.c. $KMnO_4$ = 0.0010 g. Fe, 10 c.c. contains 0.001967 g. Mn.

Traces of chlorides do not interfere, but any considerable amount should be avoided. If a large number of determinations are made daily, time can be saved by using "Analoid Tablets" (see reference 8).

Total Iron. This is usually less than 0.002 g. per liter. To about 200 c.c. of neutral solution add *two drops only* of H_2SO_4. Add weak $KMnO_4$ from a burette to a faint pink end-point. Treat 25 c.c. with salicylic acid and compare with standard. (See "Total Iron in Leach Solution," above.)

Any considerable amount of strong acid destroys the color. Acetic acid may be present, but large amounts of Na or Zn acetate weaken or modify the color so as to render the test useless.

Arsenic. This is seldom determined at our plant, being present only in traces in the pure electrolyte. We should say that the Gutzeit method might be applied here. (Reference 6.)

CaO and MgO. Pipette 20 or 40 c.c. of solution, add 20 to 30 g. NH_4Cl and 3 g. ammonium persulphate. Dilute to 75 c.c., add 15 c.c. NH_4OH, boil 8 min., and filter by suction on fine papers, to remove Mn. Wash with dilute NH_4OH.

To the filtrate add 1 g. oxalic acid, or ammonium oxalate, boil, filter, and wash once with NH_4Cl solution. Dissolve the precipitate in hot 1:3 HCl, add a little NH_4Cl and oxalic acid, dilute to about 60 c.c., make alkaline with NH_4OH, boil and filter. Wash well with hot water and determine CaO as usual.

Combine the two filtrates from the calcium oxalate and determine MgO by the usual phosphate method, making a double precipitation.

"Cell Tail" Solution

H_2SO_4. Pipette 10 c.c. of solution into a beaker. If the solution contains suspended MnO_2 or the pink color of $HMnO_4$, add a very small pinch of ferrous sulphate and agitate until colorless. Dilute to 100 c.c. with distilled water, add methyl orange, and titrate with Na_2CO_3 (22 g. per liter) until the pink color has just disappeared and the solution is pure straw yellow. (1 c.c. = 0.020 g. H_2SO_4.

Add the Na_2CO_3 drop by drop when approaching the end-point; otherwise, the end-point will be passed before the indicator changes color, on account of the precipitation of zinc carbonate.

Unless H_2O_2 is available that is free from acid it should not be used to destroy the $HMnO_4$. This destruction of the $HMnO_4$ uses up some of the acid in the solution, but not enough to affect the results to any appreciable extent. $HMnO_4$ often destroys the indicator color or produces a false end-point which occurs too soon.

Determinations of other elements are made as given above.

Ores and Residues

Concentrates, Calcines and Leach Residues

Total Soluble Zinc (acid soluble + water soluble). The following method is due to C. A. Hansen of the General Electric Co., and gives the percentage of the total zinc solubles in 6 per cent H_2SO_4 under ordinary leaching conditions:

To 0.5, 1.0, or 2.0 g. of ore add 100 c.c. of hot dilute H_2SO_4 (7.5 g. per liter). Boil 5 min., cool 1 or 2 min., add a little NH_4Cl, 5 c.c. H_2O_2 (or ammonium persulphate if much Mn is present), then add 10 c.c. NH_4OH. Boil, filter and determine zinc as usual in the filtrate.

Actual tests have shown that the above result agrees closely with the zinc actually dissolved from calcines under leaching conditions at our plant.

Water-Soluble Zinc. Leach the sample with hot water, filter, precipitate Mn by boiling with NH_4OH and ammonium persulphate, filter and determine zinc as usual. The addition of $CuSO_4$, as in the case of zinc in "Pure Electrolyte," is helpful in determining the end-point.

Uranium nitrate usually gives a more satisfactory end-point than the acetate.

Cadmium. Dissolve 4 g. finely ground ore in HCl and HNO_3, add 15 c.c. H_2SO_4, and boil to fumes of SO_3. Cool, dilute to 100 c.c., boil, and filter, washing with small volumes of water.

To the filtrate add, with stirring, 4 or 5 c.c. 10 per cent Na_2S, heat nearly to boiling and pass in H_2S until Cu is completely precipitated (about 30 min.). Heat to boiling and filter hot, washing with hot water. CdS remains in solution in the above strength H_2SO_4 when the solution is hot.

Cool the filtrate, add 15 c.c. NH_4OH, cool, dilute to 200 c.c., and determine Cd exactly as in "Leach Solution," from the point where the Cu has been removed and NH_4OH added.

Manganese. Dissolve 1 g. ore in HCl and HNO_3, add 10 c.c. H_2SO_4, and boil to fumes. Cool, dilute to about 75 c.c. with distilled water, and heat to boiling. Cool, dilute to 100 c.c. in measuring flask, mix well, take a 20 c.c. aliquot and determine Mn as in "Pure Electrolyte."

Sulphur Present as Sulphate. Take a factor weight of ore, or any convenient fraction of the factor weight, add about 4 g. of c.p. $HNaCO_3$, then add 60 c.c. of boiling distilled water and boil gently 30 min. This converts practically all sulphates except $BaSO_4$ to the soluble form. Filter hot, washing with hot water. Carefully acidify the filtrate with 4 or 5 c.c. excess HCl, dilute to 250 c.c. and determine sulphur by the usual $BaSO_4$ method. (See reference 7.)

Zinc Dust Precipitate

Copper, Cadmium and Zinc. This material consists chiefly of these metals and their oxides, with small amounts of Pb and SiO_2.

To 1 g. of the precipitate add a little water, 5 c.c. HCl and 5 c.c. HNO_3, and heat. Solution is very quickly effected. Add 15 c.c. H_2SO_4 and boil to fumes. Cool, dilute to 90 c.c., and let stand a few minutes (boiling is unnecessary). Filter off the SiO_2 and $PbSO_4$, washing with small volumes of cold water.

To the filtrate add slowly, with stirring, Na_2S (10 per cent solution of crystals) until Cu is comp'etely precipitated. About $\frac{1}{4}$ c.c. of Na_2S is required for each 1 per cent Cu present. If any CdS is observed, the Cu is completely precipitated. Boil about 2 min. The CdS dissolves again when boiled with this strength acid. Test solution with a drop of Na_2S, and filter hot, washing with hot water.

The paper containing the CuS is burned and Cu determined as usual.

Cool the filtrate, add 15 c.c. strong NH_4OH, dilute to 200 c.c., and determine Cd as in "Leach Solution."

The first filtrate from the CdS is boiled a few minutes to remove most of the H_2S, cooled, 5 c.c. H_2O_2 added, the Fe precipitated with NH_4OH, and Zn determined as usual. (See "Pure Electrolyte.")

Anode Scale From Cells

This consists chiefly of MnO_2 and PbO_2, and some Sb, probably as Sb_2O_5. Any coarse metal present should be screened out before analysis.

Antimony. To 10 or 20 g. of the scale add 100 c.c. distilled water and 15 to 20 c.c. H_2SO_4. Heat, gently at first, and add tartaric acid in small portions until the residue becomes rather light brown in color and the solution can be boiled without much foaming. Cool and filter on a Büchner funnel, washing with cold water.

To the filtrate add 60 to 80 c.c. of 3 per cent Na_2S, heat to boiling (take precautions against bumping), and treat the precipitate for antimony exactly as in "Pure Electrolyte."

Manganese. Scale to the amount of 0.295 g. is boiled with 20 c.c. of 1:1 HCl until dissolved. The chlorine may be boiled off, or it may be quickly destroyed by adding a little zinc dust, agitating a moment, and filtering off the lead sponge, etc. Mn is then determined by Volhard's method. If 1 c.c. $KMnO_4$ = 0.010 g. Fe, then 1 c.c. = 1 per cent Mn for 0.295 g. of ore.

Lead. Dissolve 1 g. of scale in HCl, take to fumes with H_2SO_4, and use Alexander's molybdate titration.

If preferred, the Mn can be determined in the filtrate from the $PbSO_4$.

References

Cadmium:
1. Blair, Chemical Analysis of Iron, 8th ed., pp. 66-68.
2. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 87.

Antimony:
3. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 27.
4. Low, Technical Methods of Ore Analysis, 6th ed., pp. 27-39.

Iron:
5. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 223.

Arsenic:
6. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 40.

Sulphur:
7. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 394.

Manganese:
8. Analoid Method for the Determination of Manganese, Scientific Materials Co., Research Dept.
9. Blair, Chemical Analysis of Iron, 8th ed., p. 125.
10. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 267.

Acknowledgments

Thanks are due to the following persons for their suggestions and co-operation: C. A. Hansen and E. R. Crutcher, former superintendents, and J. T. Ellsworth, present superintendent, of the Judge Electrolytic Zinc plant; also to K. P. Girard, formerly assistant chemist.

Chemical Industry in Holland

The *Journal* of the Society of Chemical Industry concludes from articles in the *Schweiz Chemiker Zeitung* and the *Zeitschrift für Angewandte Chemie* that things are in a bad way with Dutch chemical industries. The year 1918 was a much better year than 1919. Large quantities of Chilean nitrate have been imported, which affects adversely the fertilizer manufacturers. Great fluctuations in prices make necessary immediate deliveries of all products. Many firms have difficulty in getting export permits, while no obstacles impede the importation of manufactured wares from central Europe and products of German origin are offered below the cost of raw materials. The paper industry did well during the war, but adverse conditions have intervened. Japan and America have captured a good part of the home and foreign markets. Coal is high and so is transportation, while labor is scarce and wages are high.

The manufacture of foods, condiments, wines, etc., has a better outlook. The sugar output is below normal owing chiefly to labor conditions. Margarine production has increased and the outlook is good. Brewers lack raw materials. Ample supplies are available to the cocoa and chocolate producers, but there is trouble about exports and it is feared that the old market for Dutch cocoa and chocolate will be captured by England and Switzerland.

Nitrate Industry in Chile*

Geography, Geology and Economic Situation of Chilean Nitrate — Present-Day Recovery of Nitrate From the Raw Material Is Far From Satisfactory and There Is Urgent Need for Improvements

By ALEJANDRO BERTRAND

CHILE'S nitrate deposits are limited to a strip of territory extending between the southern latitudes 19 deg. and 26 deg., i.e., for a length of 670 km. (about 400 miles) and along the seventieth meridian. The width of the deposits is very irregular. Thus in the northern districts of Tarapaca and Toco they are found in a series of separate but narrow strips of 5 km. (about three miles) maximum width. In the Antofagasta and Aguas Blancas districts they are scattered over polygonal areas of about 40 km. (25 miles) diameter, and those of the Taltal district are at least 40 km. wide. Fig. 1 gives the geographical location of the deposits.

Although geographically the location might indicate a tropical zone, in reality it is a veritable desert and offers a great contrast with the luxuriant vegetation, climate and hydrography of the Brazilian coast along the same latitudes. There is only one river worth mentioning in the nitrate region, the Rio Loa. The Cordillera de la Costa, sloping down to the coast, end in palisades of about 800 m. (2,600 ft.) high all along the Pacific coast and present only four outlets to the ocean: Quebrada de Tiliviche, to the Bay of Lisagua, located at latitude 19 deg., 33 min.; Rio Loa, the only water stream, at latitude 21 deg., 23 min., Antofagasta, at latitude 23 deg., 40 min., to which runs the Bolivian Railway, and the Quebrada de Taltal, at latitude 25 deg., 25 min.

There is not much rainfall in this region, but frequent clouds form heavy fogs, called *camanchacas*, which render the atmosphere damp and cover the soil with dew. The wind blows regularly from west to southwest, especially in the afternoons; it often reaches a great force and acts as a strong erosion factor. The temperature varies between 25 and 35 deg. C. (77 and 96 deg. F.) during the day and between 4 and 8 deg. C. (40 to 46 deg. F.) during the night. Freezing temperature occurs only exceptionally.

Many symptoms show the existence of a strong radioactivity in the nitrate region. The electric tension of the atmosphere is sufficiently strong to produce visible sparks when rubbing woolen clothes and to cause frequent telegraphic and telephonic disturbances.

Administrative Districts of the Nitrate Region

All the nitrate deposits are grouped into five administrative districts:

1. The Tarapaca district is the oldest and comprises a number of contiguous concessions. It is served by three railways (one broad gage and two narrow gage) connecting the workings with the harbor of Pasagua and Iquique. Branches extend to Junin and Caleta Buena. This district extends to about 21 deg. south latitude, south of which there is about 100 km. (62 miles) of land in which no nitrate deposits have yet been located.
2. The Toco district covers a length of about 70 km.

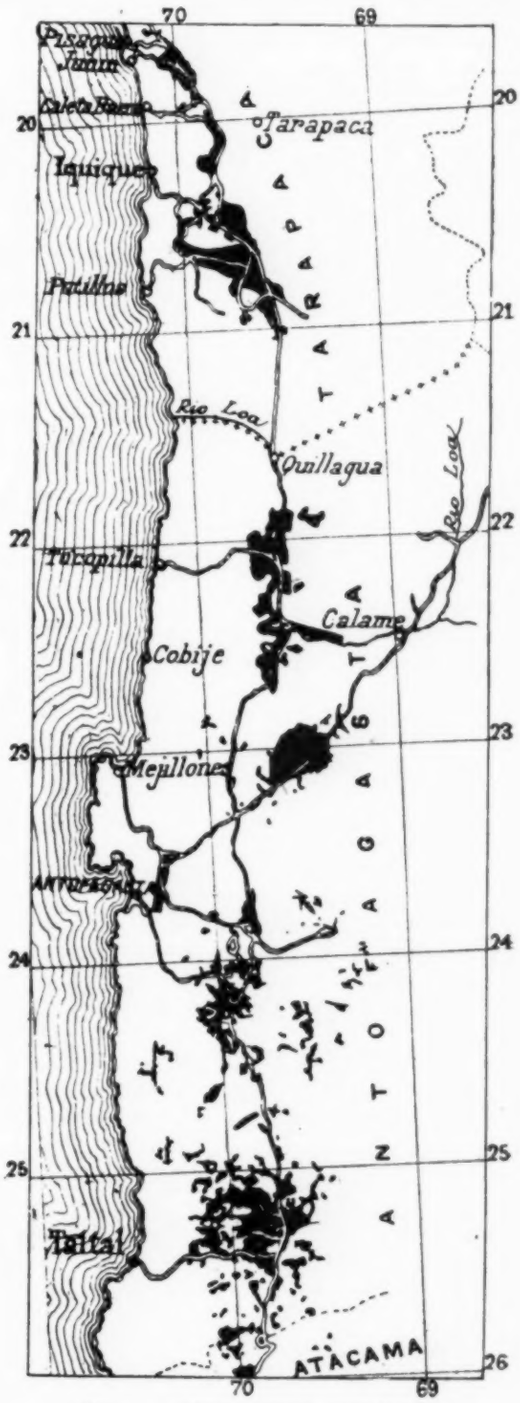


FIG. 1. GEOGRAPHIC DISTRIBUTION OF THE CHILEAN NITRATE

*Abstracts from a paper presented at the Nov. 26, 1919, meeting of the Société de Chimie Industrielle and printed in the January, 1920, issue of *Chimie et Industrie*.

FIG. 2. TYPICAL CHILEAN NITRATE PLANT

(44 miles) on the left bank of the Rio Loa. Its maximum width is about 20 km. (13 miles).

3. To the south of Rio Loa the nitrate deposits form two convergent series joined near the harbor of Antofagasta (latitude 23 deg., 38 min.). The first consists of scattered and insufficiently explored deposits in intermittent depressions, the second constitute the exploited saltpeter district of Antofagasta, whose maximum width is 15 km. (9.5 miles). It is served mainly by the Bolivian Railway.

4. Between latitudes 23 deg. 30 min. and 24 deg. 40 min. there are a number of groups of deposits, the principal group being the Aquas Blancas, 80 km. (about 50 miles) long, north to south, and 40 km. (about 25 miles) wide, east to west.

5. After a few kilometers of practically sterile land the nitrate deposits reappear, reaching the maximum width of 90 km. (56 miles) and ending at about south latitude 26 deg.

There are nine harbors to which the mined nitrate is taken for exportation. Table I shows the export tonnage capacity in metric tons of these harbors.

TABLE I. HARBORS AND THEIR EXPORT TONNAGE CAPACITY

Name	Yearly Capacity	Name	Yearly Capacity
Pisagua	120,000	Mejillones	550,000
Junin	80,000	Antofagasta	480,000
Caleta Buena	310,000	Coloso	200,000
Iquique	700,000	Taltal	300,000
Tocopilla	260,000		
Total			3,000,000

Table II gives the railways which reach these harbors, their gage, total length and average yearly tonnage.

The different railway gages are a great handicap to their efficient utilization, as can well be imagined.

Formation of the Nitrate Deposit

The nitrate deposits form generally horizontal beds covered usually by three distinct superposed layers. In some places one or even two of these layers may be missing.

TABLE II.

Name of Railway	Width of Gage in Meters (1 Meter = 3.281 Ft.)	Length in Km. (1 Km. = 0.6214 Miles)	Nitrate Metric Tons (Metric Ton = 1.102 Short Tons)
Nitrate Railways Co.	1.44	607	1,000,000
Junin	0.76	90	80,000
Aqua Santa	0.76	116	300,000
Tocopilla Railways	1.07	122	260,000
Bolivia and Aquas Blancas Rys.	0.76	600	1,060,000
Taltal Railways	1.07	350	300,000
Lonjitudinal	1.00	630	
			3,000,000

A typical vertical section shows the following arrangement:

1. A layer of "chuca," which is a gray incoherent mass containing 45 to 65 per cent of quartzose silica and quite variable proportions of nitrates, chlorides, sulphates, carbonates, phosphates and iodates of potassium, magnesium, calcium, iron, aluminum, manganese, etc. The clear color indicates an appreciable quantity of crystallized sodium sulphate.

2. Next, a layer of "panqueque" (from the English pancake), a spongy, less friable variety of chuca, richer in calcium sulphate.

3. "Costra" (crust), next below, a kind of breccia of a color varying from dark brown to light gray. Costra contains from 40 to 70 per cent of insoluble matter. Among the soluble salts between 10 and 15 per cent is sodium nitrate. This layer is intimately associated with the following layer, which is the "caliche," the useful nitrate deposit.

Caliche, Its Composition and Properties

"Caliche" is an extremely complex and variable conglomerate. Its insoluble matter is cemented by a great variety of soluble salts. The proportion of insolubles varies from zero to 50 or even 60 per cent. The maximum percentages of the most important of the salts are shown in Table III. The salts for which the percentage is not indicated are usually present in small quantities or completely absent.

TABLE III. MAXIMUM OF THE MOST IMPORTANT SALTS CONTAINED IN CALICHE

	Per Cent Maximum		Per Cent Maximum
Sodium nitrate	80.0	Potassium sulphate	....
Potassium nitrate	5.0	Magnesium sulphate	....
Magnesium nitrate	....	Calcium sulphate	*10.0
Calcium nitrate	....	Aluminum sulphate	*8.0
Sodium chloride	60.0	Iron sulphate	....
Potassium chloride	....	Potassium perchlorate	....
Magnesium chloride	1.0	Sodium sulphonitrate	....
Calcium chloride	....	Calcium iodate and borate	....
Sodium sulphate	10.0	Sodium iodochromate	....

* Exceptional.

The caliches are classified according to their properties and their content in nitrates and other soluble salts.

Color. The color varies from white to black (manganic and ferrous), brown (earthy and argillaceous), sulphur yellow (chromous), orange (bromine salts), violet (iodine salts), etc.

Structure. The physical structure is extremely vari-

FIG. 3. VIEW OF A NITRATE DEPOSIT

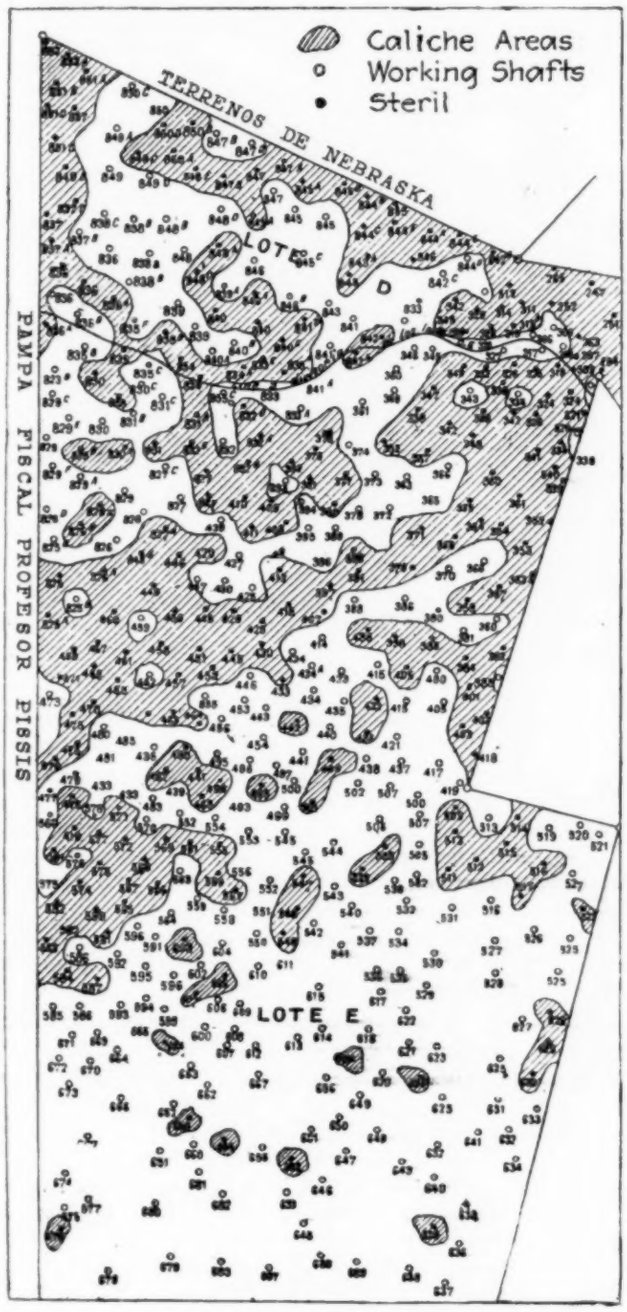


FIG. 4. PLAN OF A PROSPECTING CLAIM

able and has a great influence on the success of lixiviation. Breccia-like is the most common structure, with stony nodules of medium hardness. Others are porous, spongy, argillaceous and very compact (bony). Some are hydroscopic due to their contents of calcium nitrate.

Hardness. Hardness is a function of the structure. This property is of importance and serves to classify the caliche on the basis of the facility with which it is crushed.

Density. The density is not over 2.3 and can be as low as 1.9; for spongy caliche (45 to 52 per cent voids), it is 1.25 and even 1.0.

Substrata

Continuing in the typical vertical section there are usually three strata underlying the caliche, namely:

1. "Conjelo," which is breccia-like, the cement being sodium chloride and sulphate. The proportion of these salts may reach up to 75 per cent. Sometimes this conjelo is missing or is thoroughly intermingled with the caliche.

2. "Banco." This is also in the form of a breccia containing, besides sodium chloride and sulphate, some sodium nitrate, gypsum, etc.

3. "Coba." This is always present. It is composed of an earthy mixture with pebbles. It rests on volcanic rocks which constitute the skeleton of the Cordilleras.

It is impossible to fix the average thickness of the various layers. Caliche is never thicker than 2 m. (6.5 ft.), but coba can reach a thickness of 20 m. (65 ft.).

Prospecting for Nitrates

No plausible explanation of the origin of the deposits has as yet been given. This is a remarkable example of the imperfect human knowledge about nature's processes in the formation of a product existing on such a big scale as the Chilean nitrates.

Fig. 3 gives an idea of the usual appearance of a nitrate deposit.

A typical example of a prospecting claim is shown in Fig. 4. It is a portion of a plan published by the Chilean Government and shows the prospecting done since 1910. The government keeps geologic records on all the shafts.

The workmen have a practical way of judging the quality of caliche. They throw a small quantity of a pulverized sample on incandescent tinder. Caliche with less than 5 per cent nitrates does not give sparks, with 6 to 10 per cent nitrates the sparks are barely visible, with 10 to 20 per cent the sparks are more and more visible and numerous, with 20 to 30 per cent the sparks are visible in full sunlight. Caliche with more than 35 per cent nitrates will produce complete deflagration and flames appear. Sodium chloride decrepitates.

The prospecting holes are usually 100 m. (330 ft.) apart. Augers and scoops are used in the rudimentary prospecting work, explosives being employed but seldom.

Tables IV and V show typical examples of obligatory reports to be presented to the Chilean Government.

Separation of the Nitrate

The nitrate being present in the form of a mixture with other soluble salts and insolubles, its separation does not require any chemical reactions. Theoretically this separation appears to be extremely simple, because the only other soluble salt found in appreciable quantity in the caliche is sodium chloride and the solubility curves found experimentally and shown in Fig. 5 suggest an easy and purely physical separation of the nitrate from the chloride.

Experience has proved that the separation of the nitrate and chloride can be made to a limit of only 6 per cent chloride in solution by dissolving the caliche in boiling water. By cooling this solution to 0 deg. C. nearly 88 per cent of the nitrate free of chloride is precipitated.

This method of separation, although very simple in theory, is neither economical nor efficient, due to the great quantity of heat required and other physical conditions.

Methods of Separation

Two methods of operation are to be considered in practice. First, whether all the mass of caliche and insolubles shall be treated to boiling temperature with

TABLE IV. TYPICAL ECONOMIC SHEET OF A PROSPECTING NITRATE LOT

Santa Laura

	Sq. Meters
Area of the caliche deposit	1,063,949.76
Area sterile	305,426.00
Total area	1,369,370.76
	Number
Holes indicating the presence of caliche	144
Holes sterile	40
Total number of prospecting holes	184
	Meters
Average thickness of caliche	0.980
Average thickness of sterile ground	0.705
Total thickness	1.685
	Per Cent
Average nitrates in caliche	16.39
Average chlorides in caliche	20.00
Average iodine in caliche	0.0665
Average sulphates in caliche	7.36
Theoretical volume of the caliche, cu.m	1,042,665.860
Quantity of caliche per cu.m., tons (Average density, 2.231)	2.231
	Tons
Total weight of caliche	2,226,187.53
Less 23 per cent waste	535,023.13
Weight of working caliche	1,691,164.40
Weight of recuperable nitrate	293,571.85

the solvent. Second, whether there shall be a preliminary separation of insolubles at ordinary temperature and then treat the solution for the separation of nitrate by heating and cooling. The first method is the one which finds favor with the nitrate producers.

In the early days of the working of the Chilean nitrate (during the first half of the nineteenth century) only the caliche containing over 50 per cent nitrate (usually 60 to 80 per cent) was thought worth working.

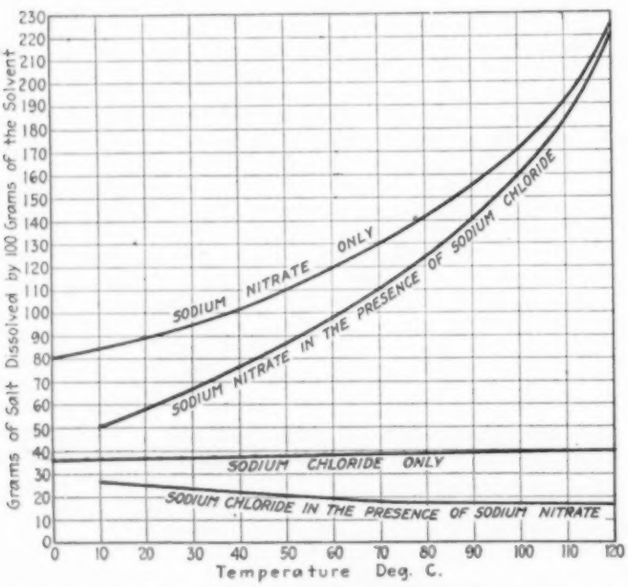

Grams of Salt Dissolved by 100 Grams of the Solvent
Temperature Deg. C.
SODIUM NITRATE ONLY
SODIUM NITRATE IN THE PRESENCE OF SODIUM CHLORIDE
SODIUM CHLORIDE ONLY
SODIUM CHLORIDE IN THE PRESENCE OF SODIUM NITRATE

FIG. 5. SOLUBILITY CURVES OF SODIUM NITRATE AND SODIUM CHLORIDE

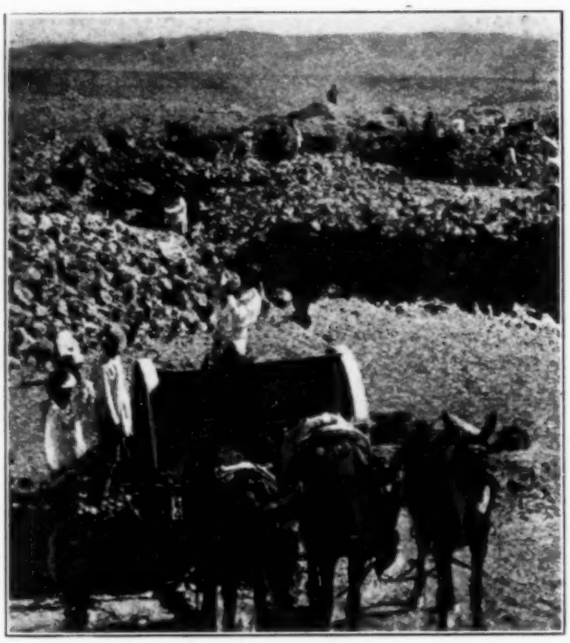


FIG. 6. METHOD OF TRANSPORTING THE CALICHE FROM THE MINE TO THE PLANT

This caliche was placed in round open tanks, treated with water, heated by open fire to boiling temperature; the solution decanted into settling tanks, where the insolubles in suspension and the sodium chloride were separated. The clarified solution was then transferred to crystallization vats or "bateas." The residue in the settling tanks usually retained from 15 to 25 per cent nitrate. This was sometimes re-treated with a new batch of caliche, but oftener it was considered as waste. Previous to 1856 about 200,000 tons of nitrate was obtained by this rudimentary method.

Beginning with 1856 improved methods of treatment were introduced. The first improvement was the substitution of steam heating for direct fire heating of the dissolving tanks. This improvement served two purposes, namely: To avoid burning the bottom of the tanks, and to agitate the mass by injection of live steam under a pressure of 3 to 4 kg. per sq.cm. (43 to 57 lb. per sq.in.). Tanks were, therefore, replaced by rectangular boilers of the Cornish type.

Next, direct steam heating was replaced by indirect steam heating.

These were the principal improvements during the period 1856-1876 when about 4,000,000 tons of nitrate was produced from caliche containing an average of 50 per cent nitrate.

The above rudimentary processes of operation resulted in excessive accumulation of residue "borras" from the

TABLE V. TYPICAL EXTRACT OF THE PROSPECTING SHEET AT SANTA LAURA. LOT D

Number of Prospecting Hole	Thickness of Superposed Layers, Meters: Sterile	Crust	Thickness of Caliche, Meters	Thickness of Subtrata, Meters	Total Thickness, Meters	Percentage Contents: Nitrates: Crust	Caliche	Chlorides	Iodine	Sulphates	Product (Thickness Multiplied by Percentage Contents)
239	0.20	....	1.20	0.85	2.25	....	17.3	....	.....	....	20.760
240	0.25	....	1.25	1.50	3.00	....	16.5	23.8	0.0291	9.56	20.625
246	0.80	....	1.20	0.75	2.75	....	12.8	....	.....	....	15.360
247	0.75	....	0.75	0.95	2.60	....	18.8	....	.....	....	14.100
248	0.40	....	0.90	1.27	2.57	....	15.0	....	.....	....	13.500
249	0.16	....	0.67	2.12	3.95	....	10.2	....	.....	....	6.834
250	0.15	....	1.55	1.50	3.20	....	11.5	....	.....	....	17.825
251	0.10	....	0.90	1.67	3.67	....	17.2	....	.....	....	15.480
252	0.90	....	0.75	2.30	4.05	....	16.7	....	.....	....	12.525
253	2.30	0.70	....	0.38	3.38	7.4	....	....	.....	....	5.180
254	0.22	2.08	....	2.05	4.35	11.4	....	....	.....	....	29.952

NOTE: 1 m. = 3.281 ft. 1 sq.m. = 10.76 sq.ft.

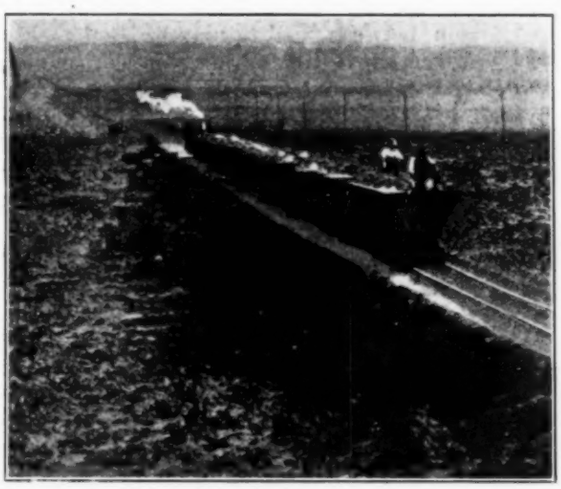


FIG. 7. RAIL TRANSPORTATION OF CALICHE

treatment, which residues contain up to 50 per cent of that nitrate originally in the caliche, in addition of the untreated waste "ripios," containing up to 30 per cent nitrate.

In 1876 the Shank process of lixiviation was introduced, thus enabling the treatment of caliches of poorer percentages of nitrate. Since first introduced it has been adopted by hundreds of plants and about 55,000,000 tons of nitrate has been thus extracted from the caliche.

This process, in which all the raw caliche and the solvent are brought to boiling temperature (the above-mentioned first method of operation) was a great improvement over the previous process during the early years of its introduction, because then the caliche treated contained on the average 50 per cent nitrate and only maximum 20 per cent of insolubles, and the useless heating of this last amount was relatively small. At the present time the Shank process is expensive and inefficient, because the caliche to be treated contains at the most 17 per cent nitrate and the insolubles reach about 60 per cent. These conditions require ever-increasing quantities of water per unit of nitrate produced and a corresponding increase in fuel consumed. Whereas in 1885 the separation of twelve units of nitrate required a consumption of one unit of fuel, now only five and in some cases as little as two and a half units of nitrate are produced per unit of fuel. Besides, the nitrate recoveries by the process do not exceed 60 per cent, the average being 50 per cent, although the contents of the ripios have been reduced to even less than 5 per cent.

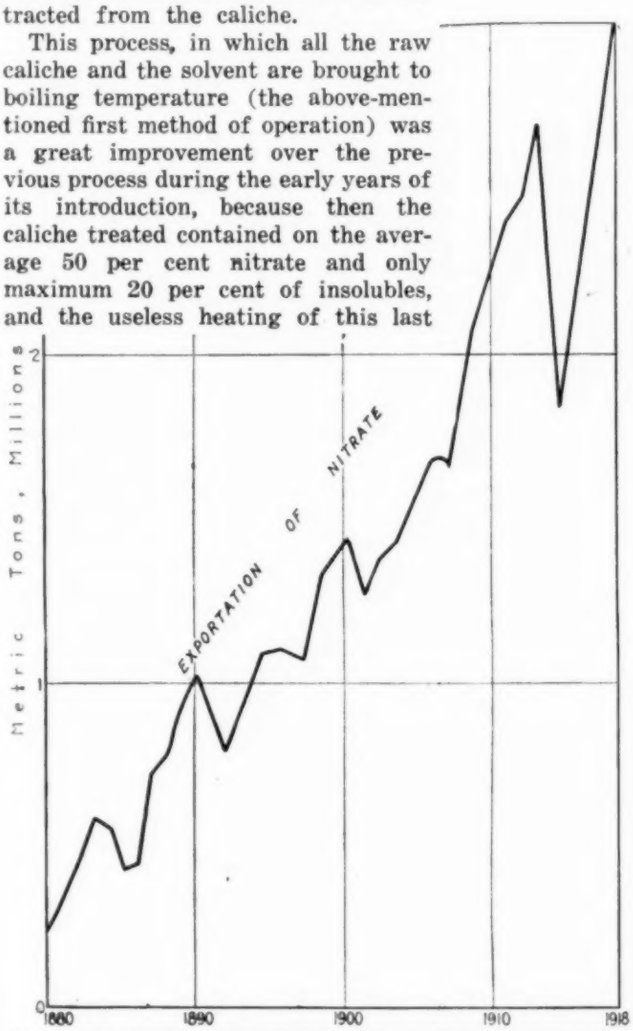


FIG. 8. PROGRESS OF THE EXPORT OF CHILEAN NITRATE FOR THE PERIOD 1880-1918

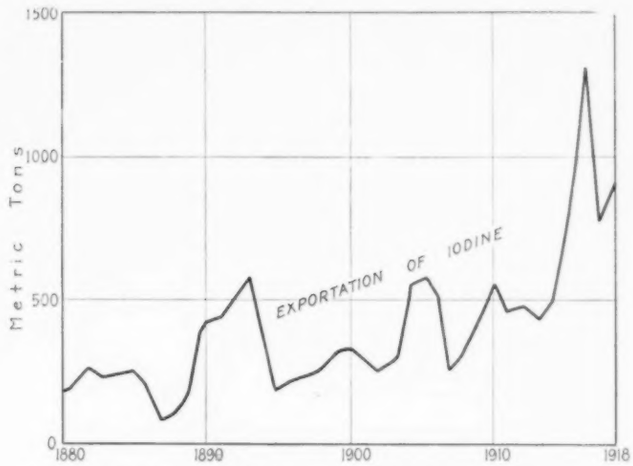


FIG. 9. PROGRESS OF THE EXPORT OF IODINE FOR THE PERIOD 1880-1918

Need of an Improved Process

Up to the present the processes for the separation of the sodium nitrate from the caliche are based on the preparation of a hot saturated solution, from which the sodium nitrate crystallizes on cooling.

It is to be expected that other factors will be taken into consideration when improved processes are looked for, such as the use of reagents with catalytic effects.

TRANSLATOR'S NOTE: The author finishes by making a strong plea for technical research leading to a more efficient treatment of the Chilean nitrate, and states that in a subsequent paper he will dwell at length on the technologic questions involved in the treatment of caliche.

Industrial Growth in Norway

According to an official report bearing upon the industrial development of Norway from 1897 to 1917, the population of Norway increased from 2,157,000 to 2,629,000 inhabitants. Within the same period the number of industrial establishments increased from 9,422 to 32,174. During this period the increase of 22 per cent in the population of the country was accompanied by an increase of 112 per cent in the number of industrial workers of various kinds. The number of horsepower in Norway in 1917 was 1,613,283, as compared with 172,397 in 1897. The increased use of electricity for motive power is evidenced by the fact that in 1900 there were only 417 electric motors in all Norway, and their total capacity was only 4,121 horsepower. In 1917 there were 26,040 motors with a capacity of 342,251 horsepower.

Synopsis of Recent Chemical & Metallurgical Literature

Strength of Steel at High Temperatures.—G. P. McNIFF, in a written discussion, called attention to various independent researches corroborating the results obtained by H. J. French on the Tensile Properties of Boiler Plate at Elevated Temperatures, presented before the February meeting of the A.I.M.E., and abstracted in CHEMICAL & METALLURGICAL ENGINEERING for March 3, 1920, vol. 22, p. 393. He presented several photographs pertinent to this subject, of an experiment carried out at the Shelby works (Ellwood City, Pa.) of the National Tube Co., during 1913 and completed in January, 1914. One of the photographs showed a general view of the testing machine with the test piece in place surrounded by an electric tube furnace very similar to the set-up used by French. A Le Chatelier rare metal thermocouple was used for the temperature readings.

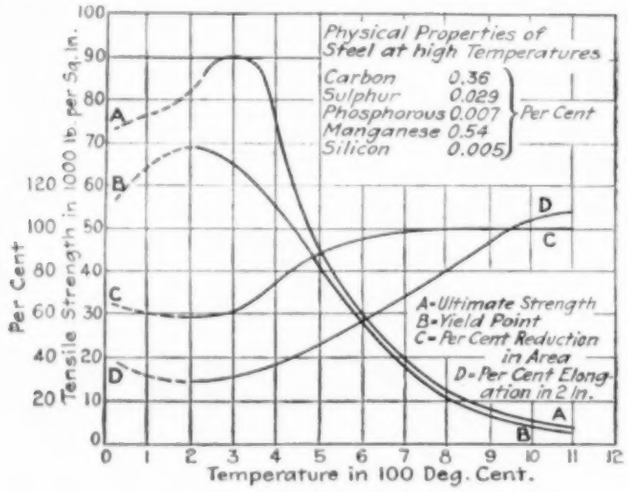


FIG. 1.

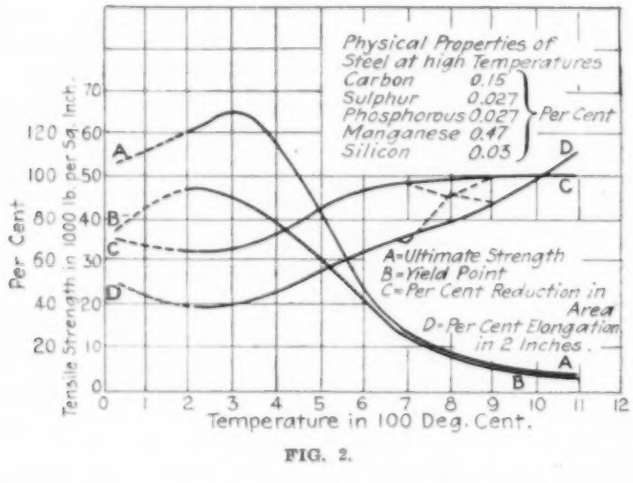


FIG. 2.

The material investigated was seamless tubing of several different carbon contents. A summary of the results obtained is shown on the curves attached. Fig. 1 gives results on a 0.36 per cent carbon steel, Fig. 2 on a 0.15 per cent (boiler tube grade) and Fig. 3 gives a comparison between the results of Kollmann[1] and Howard[2] previous investigators on this subject, results at the Shelby laboratory and those obtained recently by French.

In each case the results obtained are fairly concordant and seem to indicate that for all carbon steels their strength and characteristics at temperatures above normal are a direct function of these same characteristics at normal temperatures, and show no great variation with the carbon content.

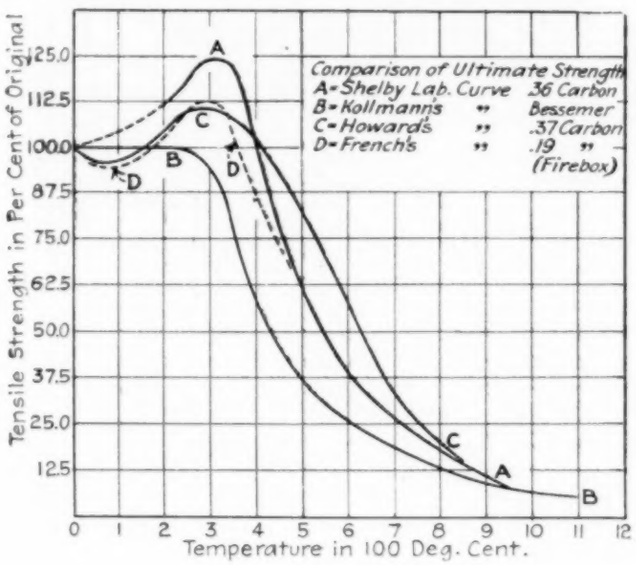

Comparison of Ultimate Strength
A-Shelby Lab. Curve .36 Carbon
B-Kollmann's " Bessemer
C-Howard's " .37 Carbon
D-French's " .19 " (Firebox)
Tensile Strength in Per Cent of Original
Temperature in 100 Deg. Cent.

FIG. 3.

H. D. Hibbard also mentioned that the Watertown Arsenal[3] had obtained very similar results a great many years ago.

British Blast-Furnace Practice.—According to the *Engineer*, March 5, 1920, vol. 129, p. 246, the paper which W. H. BUCKLEY, M.I. Mech. E., read on "British Blast-Furnace Practice" before the members of the Manchester Association of Engineers on Feb. 28 covered a large amount of ground, including descriptions of the furnace stack, stoves, and connections, dust catchers, charging arrangements, storage arrangements, pig-bed equipment, slag disposal, blowing plant, boilers, pumping plant, and gas-cleaning plant. The author said that the prevailing conditions in connection with British blast furnaces were open to considerable improvement in many directions. Future blast-furnace plants were not likely to exist as isolated units, but they would be operated in conjunction with and in close proximity to coke ovens and steel works. Thus the cost of handling and the loss of heat would be reduced to a minimum. Mr. Buckley said that electrical smelting on a large scale was not likely to be developed in the immediate future, until such times as our potential sources of power production were further developed. Enrichment of blast with oxygen had been tried in Belgium, but so far it was not a practicable success. The conservation of heat about a blast-furnace system was likely to receive more attention in future. Radiation losses could be considerably reduced if efficient means of insulation were provided. The recovery of heat from slag was also a question of vital importance, and so far only experimental work in that direction had

[1] *J. Frank. Inst.*, vol. 112, p. 241 (1881).
[2] *Iron Age*, April 10, 1890.

been carried out. If slag be granulated in water so that low-pressure steam be developed, such steam was not fit for use in low-pressure turbines, and an intermediate system of evaporation must be introduced, but there did not appear to be any reason why such dirty steam—which, incidentally, contained about 5 per cent of incondensable gases—should not be used for gas producers, in conjunction with air blowers. Potash was already recovered in large quantities from the fine dust in the gas, and the coarser dust—which had a comparatively low potash content—was likely to have a higher value in future, as some might be used on plants nodulizing fine ores. If waste heat could not be satisfactorily utilized for steam raising, there was a big field for the use of it in either drying ores or preheating blast, or air for combustion.

Nickel:Chromium Alloys and Thermocouples.—W. A. GATWARD recently read a paper on this subject before the Engineers' Society of Western Pennsylvania, in which he sketched the development and present status of this industry. Since both constituents melt at a high temperature, nickel takes carbon into solution, and chromium is easily oxidized, the alloys are very difficult to make. At no time in their development was it possible to predict the properties of untried combinations. Since 1906 about 2,000 tons of Ni:Cr metal has been used in the manufacture of heating devices alone. They actually contain varying percentages of Mn, Al, Fe or Si. Seven commercial alloys are described which may be used for heating elements, all of them quite durable at 800 deg. C. As the temperature goes up, their life rapidly shortens. The best of them, however, rapidly assume a closely-adhering coat of protective oxide. The author lists thirteen requisites of a good heating element. Principal among them is a low temperature coefficient. Experience shows that the presence of a cold body near a certain part of a heating element causes that portion to advance slightly in temperature. If the wire possesses too large a coefficient, this will cause that portion to become increasingly hotter until it melts.

Specific resistance should be high so that large sections and short lengths are possible for a given resistor. This is responsible for rugged elements, small in bulk, operating at a low temperature. It is desirable but apparently impossible to obtain a high heat conductivity at the same time, in order that the heat developed below the surface of the wire can be radiated effectively.

Nickel:chromium alloys have been invaluable in pyrometry, producing the first good positive element for base-metal couples. The secret of their success is proper protection, maintaining a strictly oxidizing atmosphere at all times. If graphite, carborundum or silfrax protecting tubes are used, a gas-tight lining should be provided. Luckily one of the same alloys, "chromel," is impervious to CO at working temperatures, and can therefore be used for this purpose.

If fusible material of almost any kind comes in contact with the hot wire, the protective scale is destroyed and a burn-out soon follows, from this cause if not from short-circuiting. Cyanide and sulphur fumes also cause rapid deterioration. Welding of clean surfaces may be done by feldspar and flame or an electric arc. Carburizing boxes or other sound castings can now be made weighing up to 1 ton and to 15 ft. long. Such pieces would have walls about 1 in. thick, or somewhat heavier than cast iron. They resist molten lead quite well.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Chlorpicrin.—The process of preparing chlorpicrin by treating picric acid with bleaching powder in the presence of water is difficult to control. The reaction is violent; the evolution of CO_2 and HCl and the absorption of these gases in the $Ca(OH)_2$ simultaneously produced cause foaming; the heating is excessive; the yield varies from zero to nearly theoretical without apparent reason; oxidation occurs, reducing the yield by the formation of resinous byproducts. ROBERT J. KING of Stamford, Conn., prefers the following: 10.8 parts of calcium picrate is dissolved in about 30 parts of water and added gradually to a solution of 88 parts of bleaching powder (35 per cent available chlorine) in 170 to 770 parts of water. A vigorous reaction takes place and the yellow color of the mixture rapidly disappears. The chlorpicrin is separated by steam distillation. (1,327,714; Jan. 13, 1920.)

Powdered or Granulated Aluminum.—When molten aluminum is subjected to violent agitation during cooling, at a temperature just below the melting point the mass will be broken up into granules. The degree of granulation may be controlled by the violence of the agitation. (1,327,743; LEWIS B. TERRETS, 2d, of St. Louis, Mo.; Jan. 13, 1920.)

Synthetic Ammonia.—When air or nitrogen is passed through a solution in which nascent hydrogen is being evolved, ammonia is formed. The nascent hydrogen may be produced electrolytically or by the action of acids or alkalis upon appropriate metals. (1,328,082; ROBERT F. GARDINER of Clarendon, Va.; Jan. 13, 1920; application filed under the act of March 3, 1883.)

Explosive.—There are two classes of high explosives similar in their explosive properties to existing standard grades of dynamite. The first comprises mixtures of small percentages of TNT with nitroglycerine for the production of the so-called low-freezing dynamite. These are expensive to manufacture, the liquid constituent tends to exude, and users are liable to contract severe headaches in handling the explosive. In the second class, low percentages of TNT are used with relatively large percentages of explosive salts having a high oxygen content such as ammonium nitrate, ammonium perchlorate, potassium chlorate, etc. These explosives are relatively insensible to detonation, are liable to become extremely hard in storage and are usually very dusty. A more satisfactory explosive is suggested by LEON O. BRYAN and WENDELL R. SWINT of Wilmington, Del. The following composition is typical: Nitrogycerine, 5 per cent; trinitrotoluol, 40 per cent; sodium nitrate, 55 per cent. Other examples are given which are equivalent to standard industrial dynamites. (1,327,859; assigned to E. I. du Pont de Nemours & Co.; Jan. 13, 1920.)

Calcium Carbide and Wood Distillation Products.—JAMES HENRY REID of Newark, N. J., describes a process for the production of wood distillation products and calcium carbide in one operation. A mixture

of sawdust and calcium oxide is heated in an electric furnace. At first products of the destructive distillation of the sawdust are obtained. Later, the temperature is raised until calcium carbide is formed. In a modification, coking coal is used instead of sawdust. A third patent describes an automatic controlling device for the furnace electrodes. (1,327,736; 1,327,737; 1,327,738; assigned to International Nitrogen Co.; Jan. 13, 1920.)

Purifying Ammonium Sulphate.—Damp crude ammonium sulphate crystals containing free acid, pyridinc bases or sulphates of pyridine bases are placed in rotary container and heated to about 250 deg. F. by a current of hot air. Simultaneously, ammonia vapor is passed into the container. Ammonium sulphate is formed by neutralization of the free acid and the pyridine sulphates are decomposed. The pyridine bases are volatile at this temperature. The final product is dry ammonium sulphate, free from acid and pyridine. (1,328,342; WILLIAM A. SLOSS of Toledo, Ohio; Jan. 20, 1920.)

Sulphuric Acid Manufacture.—The efficiency of the chamber process is increased by removing the acid mist which forms in the first chamber and passing it through an electrical precipitator. The presence of the mist particles of nitrosyl sulphuric acid in the chambers tends to inhibit the completion of the reaction. Additional advantages claimed by HARRY V. WELCH of Los Angeles, Cal., are: Circulation of the gases in the chamber by withdrawing the vapors at one end of the chamber and returning them (after having passed through the precipitator) at the opposite end; cooling of the gases so that the heat of reaction does not raise the temperature above the optimum. Chamber acid flows through the precipitators and the strong acid thus formed is fed to the Glover tower. (1,328,552; assigned to International Precipitation Co.; Jan. 20, 1920.)

Artificially Cooled High-Frequency Coil.—The temperatures attainable in the Northrup induction furnace are materially increased by making the inductor coil hollow so that it may be cooled by water, oil, etc. Temperatures above 2,500 deg. C. may be reached. (1,328,336; EDWIN F. NORTHRUP, assignor to the Ajax Metal Co.; Jan. 20, 1920.)

Reduced Sulphite Waste Liquor.—Commercial neutral waste sulphite liquor of 30 deg. Bé. is acidified with 1 or 2 per cent of H_2SO_4 and iron filings or iron wire added. The reduction may be hastened by adding a little copper to form a couple. The reduced liquor, after removing undissolved iron and iron salts, is evaporated to 20 to 30 deg. Bé. It may be used as a dye, producing shades of greenish brown or unmordanted wool. The liquid also has considerable insecticidal value. It may be used with the usual spraying apparatus. Retaining some of the physical properties of the original sulphite liquor, it adheres well to leaves, vines, etc. (1,327,862; FRANK E. COOMBS of San Francisco, Cal.; Jan. 13, 1920.)

Sodium Ferricyanide.—The process which is commonly used for the manufacture of potassium ferricyanide from potassium ferrocyanide—namely, oxidation by means of a halogen according to the equation:

$$2K_4Fe(CN)_6 + Cl_2 = 2KCl + 2K_3Fe(CN)_6$$

fails when applied to the corresponding sodium salts. It is very difficult to separate the sodium chloride and sodium ferricyanide by fractional crystallization. ROGER WILLIAMS of Providence, R. I., has found that sodium chloride dissolves readily in anhydrous liquid ammonia while sodium ferricyanide does not. Accordingly, when the solution of the two salts is evaporated to dryness and the residue treated in a suitable apparatus with liquid ammonia, the sodium chloride is completely extracted. The final residue may be dissolved in sufficient water to form a saturated solution and allowed to crystallize. To favor the production of particularly large crystals, some additional water may be gently poured upon the top of the concentrated solution, which when allowed to stand will then deposit large red crystals. The ammonia is recovered from the solution of sodium chloride by heating, cooling and compressing. In order to reduce losses of ammonia to a minimum the apparatus employed should be air-tight. (1,328,938; assigned to Nitrogen Products Co.; Jan. 27, 1920.)

Calcium Fluoride.—When prepared by the interaction of dilute solutions of calcium chloride and hydrofluoric acid, the precipitate of calcium fluoride is slimy and great difficulty is experienced in filtering and washing. By using concentrated solutions, WALLACE S. CHASE of Lakewood, Ohio, finds that the character of the precipitate is greatly improved. If the precipitate is dried at a temperature between 100 and 150 deg. C. and then pulverized, washing and filtering may be accomplished with ease. This process of preliminary drying is also applicable to other slimy precipitates. (1,329,072; assigned, by mesne assignments, to National Carbon Co.; Jan. 27, 1920.)

Stabilizing Nitrostarch Explosives.—There are certain substances, such as rosaniline base, and diphenylamine, which are well recognized as stabilizing agents in connection with nitrocellulose products. Owing to the greater ease with which nitrostarch tends to colloid, the introduction of these materials into the manufacture of nitrostarch explosives has been limited, and accordingly the use of these valuable stabilizing agents has in a measure been prevented. The colloiding action of these stabilizers may be prevented by dissolving them in a heavy mineral oil before adding to the explosive. A further advantage is the uniform distribution of the stabilizer. (1,329,211 and 1,329,212; WALTER O. SNELLING and WILLIAM R. LAMS of Allentown, Pa., assignors to Trojan Powder Co.; Jan. 27, 1920.)

Acetone and Butyl Alcohol by Fermentation Process.—The process of fermenting carbohydrate material to form acetone and butyl alcohol, using bacteria of the amylobacter group, is accelerated by a preliminary treatment with molds or enzymes having a strong proteolytic action. The mold used must not produce organic acids or alcohols which would interfere with the subsequent fermentation. CHARLES WEIZMANN and GEORGE A. HAMLYN of London, England, cite the following example: A sterilized mash prepared from rice, corn or other grain is inoculated with *Aspergillus oryzae*, which is allowed to grow for three or four days at 30 to 37 deg. C. The mash is then inoculated with cultures of amylobacter, which normally do not produce active fermentation. Fermentation sets in very rapidly and continues for 48 to 60 hr. The product is then distilled. The yield of acetone and butyl alcohol varies from 15 to 20 per cent of the weight of grain used. (1,329,214; Jan. 27, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Chemical Warfare Service

None of the opposition which was manifested in the committee against a separate Chemical Warfare Service was voiced in the House when that section of the Army reorganization bill came up for consideration. The committee's report for a separate Chemical Warfare Service was adopted without a record vote.

In the bill proper the duties of the Chemical Warfare Service were not prescribed. This was remedied by an amendment which reads as follows:

> The duties of the Chemical Warfare Service shall comprise the investigation, development, manufacture, or procurement and supply to the Army of all smoke and incendiary materials, all toxic gases, and all gas-defense appliances; the research, design, and experimentation connected with the chemical warfare and its matériel; and chemical projectile filling plants and proving grounds; supervision of the training of the Army in chemical warfare, both offensive and defensive, including the necessary schools of instruction; reorganization, equipment, training, and operation of special gas troops.

As passed by the House the Chemical Warfare Service is to consist of one chief, with the rank of Brigadier General, ninety officers, in grades from Colonel to Second Lieutenant, and 1,500 enlisted men. An effort by Representative Dent to amend the bill so as to designate the specific number of officers of each grade, as well as the number of chemical engineers to be employed, was lost. In explaining his amendment Mr. Dent pointed out that the Chemical Warfare Service is a development of the war and that "if it has any unfriendly administration we all know that unless the personnel is fixed the Service itself is liable to prove a failure."

Mr. Dent was asked by one of the members of the House how the Service would secure its expert chemists, since the bill provides that the officers must have served during the war in order to be entitled to a commission. In reply Mr. Dent expressed the opinion that it would be necessary to get chemists from outside the military service, which he thought would be precluded by the wording of the bill. He used that as an argument for recommitting the bill to the committee so that its defects might be remedied. This the House declined to do, however.

In the course of the discussion several tributes were paid to General William L. Sibert, who until recently was the head of the Chemical Warfare Service. That the House is not satisfied with the explanation of the Secretary of War that General Sibert's removal from the Chemical Warfare Service to be commander at Camp Gordon was simply to prevent a loss of one grade in rank became very evident during the debate. It was plainly intimated that the real reason for the change in assignment, in the opinion of some members, was due to its criticism of the legislation as recommended by the General Staff. Mr. Dent declined to express himself in that connection, but said it is his personal opinion that the Chief of the Chemical Warfare Service should be a Major General rather than a Brigadier General.

Despite the pressure for a vote on the bill Mr. Dent insisted on reviewing the accomplishments of General Sibert as head of the Chemical Warfare Service, which he referred to as one of the greatest developments of the war. His reference to General Sibert is as follows:

> A native Alabamian, William L. Sibert graduated from West Point with high distinction. He was assigned to the Corps of Engineers. He performed valuable river and harbor work upon the Ohio River in particular. Without any political pull, when the Panama Canal was to be constructed, President Roosevelt selected him as one of the commissioners to build the canal. He was assigned to the specific duty of constructing the Gatun Dam and Locks. He dammed the Chagres River when the late Senator Morgan, of Alabama, who for years had advocated some form of transcontinental canal, said that that river could not be dammed. After his service there the Congress of the United States, along with the other members of that commission, extended to him its thanks, authorized a promotion above the grade that he occupied, and further authorized his voluntary retirement before reaching the age of sixty-four. This he has continuously refused to accept. After his work with the Panama Canal he was assigned to the Pacific coast in charge of the Coast Artillery as a line officer. He succeeded well and ably in that work. When the war broke out he was assigned to the organization and training of the first division that went to France.
>
> He organized it, trained it, and carried it to France. He commanded that division in France and was for a time placed second in command to General Pershing. For some reason he was returned to this country and placed temporarily in command of the Southeastern Department at Charleston, and then when the Chemical Warfare Service was established the Secretary of War very properly called General Sibert to take charge of the organization and development of that branch of the service. General Sibert took charge of it, developed it during the war, and has made out of it, in my humble judgment, one of the greatest developments that the war established.

Tungsten Bill Reported to Senate

Arguments to the effect that the tungsten resources of the United States are so limited that the existing deposits should remain untouched as a safeguard in a future emergency evidently were not accepted by the Senate Finance Committee, as it has reported favorably to the Senate a tariff bill which is believed to grant sufficient protection to permit the development of domestic mining industry. The Senate committee from its investigation found the cost of domestic production averaging $13 per unit. The data showed foreign costs to be from $2 to $4 per unit. It pointed to the fact that tungsten was selling at New York from $6 to $7.50 per unit and that fully 50,000 units per month are being imported, duty free. As the domestic mines cannot meet those prices, all of them are closed and prompt action is necessary to prevent the destruction of the industry, the committee reports. It is the belief of the committee that eventually the entire domestic requirements for this metal can be met from our own mines. During the period of development, it is pointed out, a substantial revenue should be received by the Government from importations of ore.

Fifth Annual Meeting of T. A. P. P. I.

The fifth annual meeting of the Technical Association of the Pulp and Paper Industry will be held in New York on April 13, 14 and 15. The business and technical sessions will be held at the Waldorf-Astoria Hotel and the annual banquet will take place at the Hotel Astor. The order of meetings will be as follows:

Tuesday, April 13, 9:30 a.m.

Meetings of standing committees in Myrtle Room and Room 151, Waldorf-Astoria.

FIRST GENERAL SESSION

Wednesday, April 14, 9:30 a.m., Myrtle Room

Business meeting.

Appointment of committee to nominate officers to serve during the ensuing year.

The reports of committees will be received in the following order:

Abstracts of Literature—Ross Campbell, chairman.

Bibliography—Henry E. Surface, chairman.

Groundwood—William A. Kelly, chairman.

Heat, Light and Power—Edward P. Gleason, chairman.

Paper Testing—Frederick C. Clark, chairman.

Pulp and Paper Machinery—George R. Wyman, chairman.

Soda Pulp—Martin L. Griffin, chairman.

Standard Methods of Testing Materials—E. C. Tucker, chairman.

Sulphate Pulp—Olai Bache-Wiig, chairman.

Sulphite Pulp—Herbert G. Spear, chairman.

Vocational Education—George E. Williamson, chairman.

SECOND GENERAL SESSION

Wednesday, 2 p.m., Myrtle Room

Reading and discussion of special papers:

Some Further Mill Trials on the Pulping of Second Cut Cotton Linters, by Otto Kress and Sidney D. Wells.

Testing Tearing Strength of Paper With the Elmendorf Tearing Tester, by Armin Elmendorf.

Fuel From Sulphite Waste Liquor, by George Barsky and Ralph H. McKee.

Grinding Woodpulp Efficiently, by A. F. Meyer.

Advantages of Liquid Sulphur Dioxide for Sulphite Pulp Manufacture, by Vance P. Edwardes.

3:30 p.m., Room 151

Symposium on Rag Selection and Cooking. E. C. Tucker, chairman:

1. Selection of rags and their standardization.

2. Cooking of rags: (*a*) Reasons for cooking and objects accomplished; (*b*) the cooking liquor; (*c*) the rotary boiler and drive, with special reference to any recent improvement, power consumption, etc.; (*d*) the factors of time and pressure and how cooking is influenced by them; (*e*) the washing of rags in the boiler and their handling from boiler to washer.

Wednesday Evening, April 14

Annual banquet at Hotel Astor; reception at 7 p.m., dinner at 7.30 p.m.

Guests and speakers: Raymond S. Hatch, president; Judge Charles F. Moore, toastmaster; Joseph W. Fordney, chairman of the Ways and Means Committee, House of Representatives; Prof. William H. Walker, Massachusetts Institute of Technology; Prof. Charles Baskerville, College of the City of New York; George Carruthers, president of the Interlake Tissue Mills, Ltd., Toronto, Canada; Henry W. Stokes, president of the York Haven Paper Co., York Haven, Pa.; John Stadler, Belgo-Canadian Pulp & Paper Co., Ltd., Shawinigan Falls, Canada; John E. Alexander, Nekoosa-Edwards Paper Co., Port Edwards, Wis.; Evan Davies, New York; Howard S. Neiman, New York.

THIRD GENERAL SESSION

Thursday, April 15, 2 p.m., Myrtle Room

A short session will be held prior to recessing for attendance on the general meeting of the American Paper and Pulp Association in the Astor Gallery.

Nomination and election of officers.

FOURTH GENERAL SESSION

Thursday, April 15, 2 p.m., Myrtle Room

Reading and discussion of scientific papers:

Possibilities of Developing a More Efficient Method of Extracting the Soda Salts From Black Ash, by George M. Trostel.

Improved Equipment for the Sulphite Mills, by E. R. Barker. This paper will describe a new type of limestone acid system; a new apparatus for automatic melted sulphur feed; an automatic alarm to show sublimed sulphur; a device for regulating the strength of acid in Jenssen towers, and a system for controlling automatically the strength of acids from milk of lime systems.

Methods of Cooking Control, by W. E. Byron Baker.

Limestone Analysis and Evaluation for Bisulphite Liquor Manufacture, by W. E. Byron Baker.

Sectional Individual Motor Drive for Paper Machines, by Stephen A. Staege.

The Application of Pragmatic Philosophy to the Papermaking Industry, by John W. Brassington.

Some New Methods of Waste Sulphite Liquor Recovery, by Walter H. Dickerson.

2 p.m., Room 151

Symposium on the extent to which the jordan can replace the beating engine in the production of paper. The discussion will be led by W. L. Nixon, of the Chemical Paper Manufacturing Co., and Max Zimmerman, of the Charles Boldt Paper Mills, will contribute a special paper on the subject.

A symposium is planned for the discussion of black liquor recovery with special regard to the most durable method of lining the smelters used in the sulphate recovery process. The discussion will be led by G. F. Enderlein, of the Brompton Pulp & Paper Co., Ltd., East Angus, Que., and R. M. Radsch, of the Thilmany Pulp & Paper Co., Kaukauna, Wis.

Proposed Tariff on Antimony Compounds

New tariff duties on antimony and antimony salts are proposed in a bill just introduced by Representative Watson of Pennsylvania. Antimony as regulus or metal and matte containing antimony, but not containing more than 10 per cent of lead, is to be dutiable at 10 per cent ad valorem. His bill also provides for a 25 per cent ad valorem duty on antimony oxide and a duty of 7c. per lb. and 45 per cent ad valorem on antimony salts, titanium salts, hydrosulphites, sulphoxylates and artificial bases.

Meeting of the California Section of the American Chemical Society

At the regular meeting of the California Section of the American Chemical Society held Friday, March 26, at the Engineers' Club, San Francisco, two interesting papers were presented. The first, by Dr. L. H. Duschak of the United States Bureau of Mines, on "The Chemical Basis for the Volatilization Process as Applied to Silver Ores," and the second, by Dr. W. H. Rodebush, Fellow of the National Research Council, on "Industrial Alcohol in the Industries."

Dr. Duschak reported experiments conducted at the Bureau of Mines Station in determining the vapor pressure of silver chloride at high temperatures from 980 to 1,140 deg. C. Vapor pressure of silver and of silver sulphate were also studied, as well as the possible formation of silver silicate. The experiments showed that there was no evidence of the formation of silver silicate under furnace conditions as had previously been indicated by some investigators. Investigation showed that the presence of oxygen and water vapor was necessary for a satisfacory volatilization and also that it was necessary to have an excess of chloridizing agents present to produce what Dr. Duschak termed "protective chlorination," in order to prevent the reduction of the chloride formed to the oxide or to the metal.

Dr. Rodebush reviewed the sources of supply of industrial alcohol, together with its use in the arts. He suggested the possible development of agriculture in the tropics for the production of sugar-bearing plants as a source of future supply. He reviewed the industrial possibilities of water-free alcohol and the production of ethylene-glycol and of ethyl acetate from alcohol and the use of these in industry. Ethylene is a more satisfactory substance than acetylene for use in welding. Attention was called to the fact that ethyl acetate is being used extensively as a solvent.

Cleveland Section Meeting, A. C. S.

At the March meeting of the Cleveland Section, American Chemical Society, held March 19, Dr. Charles L. Parsons gave an extremely interesting illustrated lecture on "Nitrogen Fixation." Before commencing his talk Dr. Parsons outlined the aims of the Society and told how it had become a powerful force in national affairs during the past three or four years. He cited, as an instance, the recent establishment by Congress of the Chemical Warfare Service as a separate corps against the wishes of the General Staff.

In his lecture he outlined the various processes of nitrogen fixation that held commercial possibilities in this country and described some of the plants that had been erected during the war, especially the ones at Muscle Shoals and at the Solvay plant at Syracuse. Dr. Parsons expressed the opinion that the Haber and the sodium cyanide processes seemed to offer the greatest possibilities for future development and that with the development the farmers should be educated to the use of the various nitrogenous fertilizers.

Chemical Warfare Service Stops Recruiting

No enlistments are being accepted for the Chemical Warfare Service, the Adjutant General of the Army announces, "as this branch is filled by men who are securing advanced instruction in chemistry."

Protection for Trademarks in Foreign Countries

Legislation which will bring about much needed protection to American trademarks and commercial names abroad has been approved finally by both houses of Congress and is before the President for his signature. It is expected that the President will sign the measure.

The legislation referred to is the ratification of the Buenos Aires convention, which allows American interests to file their trademarks and commercial names in an international bureau at Havana, thereby precluding separate registration in any of the South American republics.

The Latin-American countries already have ratified the convention. The bill also carried an amendment to the trademark act of Feb. 20, 1905, which adds to that law the following words:

> And if any person or corporation shall have so registered a mark upon the ground of said use for ten years preceding Feb. 20, 1905, as to certain articles or classes of articles to which said mark shall have been applied for said period, and shall have thereafter and subsequently extended his business so as to include other articles not manufactured by said applicant for ten years next preceding Feb. 20, 1905, nothing herein shall prevent the registration of said trademark in the additional classes to which said new additional articles manufactured by said person or corporation shall apply, after said trademark has been used on said article in interstate or foreign commerce or with the Indian tribes for at least one year, provided another person or corporation has not adopted and used previously to its adoption and use by the proposed registrant, and for more than one year such trademark or one so similar as to be likely to deceive in such additional class or classes.

Chemical Engineering at University of Nebraska

The department of chemistry of the University of Nebraska has introduced some new courses in practical chemistry, which have been working out very successfully. These courses were opened last September. For some years this department was not in position to offer technological chemical courses, because of lack of facilities. Now the department is housed in a very fine new laboratory and the chairman of the chemistry faculty, Dr. F. W. Upson, set about arranging for courses devoted to chemical engineering subjects. The department has also put in a course in "Oil and Gas" which is primarily for geologists. This work is in charge of Associate Professor C. J. Frankforter. Mr. Frankforter returned to the department last September, after having served twenty-two months in the Army.

Chemistry of the Earth's Crust

In an address before the Geological Society of Washington on March 24, Dr. H. S. Washington presented a recalculation of the composition of the earth's crust and the density of the earth over different areas. A very striking relationship was pointed out for the first time by Dr. Washington between the average density of the earth and the elevation above sea level. Several charts showing the relationship for both northern and southern hemispheres give almost complete agreement between the average analyses and the altitude figures. A correlation with the variation of density as measured by the pendulum method by Bowie was also given.

A new classification of the elements in the periodic system was presented, showing a systematic relationship between the elements which occur mainly in minerals and those which occur in rocks.

Civil Service Examinations

The following examinations are announced by the Civil Service Commission:

Assistant Examiner, Patent Office.—Examinations will be held April 7 to 9, May 5 to 7 and June 9 to 11 at places specified in Form 1237. Entrance salary, $1,500 a year, with temporary increase of $240 a year.

Mold Maker (Optical Glass or Ceramics).—Two vacancies exist in the Bureau of Standards; one in the position of mold maker, optical glass, at $1,680 a year in Washington, D. C., the other in the position of mold maker, ceramics, at $1,380 a year for duty in Pittsburgh, Pa. Apply on Form 1312 before April 20.

Petroleum Engineer and Assistant Petroleum Engineer (Oil and Gas Production).—Salaries, $3,000 to $4,500 and $2,100 to $3,000 a year, respectively. The closing date for receipt of applications (Form 2118) has been postponed from March 16 to April 27.

Laboratory Assistant.—Vacancies in Bureau of Construction and Repair, Navy Department, at $5.20 per day and at the U. S. Navy Yard, Washington, at $6 per day will be filled from examinations held at the usual places April 28 and 29, June 9 and 10 and July 21 and 22.

Mechanician and Laboratory Assistant.—For duty at Berkeley (Cal.) Station of Bureau of Mines at $5.25 per day. April 28 and 29, 1920.

Physicist.—Applications will be received until further notice for positions in Bureau of Standards (assistant physicist, $1,400 to $1,800 a year; associate physicist, $2,000 to $2,800 a year) and in the Signal Service of the War Department at $1,500 to $1,800 a year.

Laboratory Assistant.—Applications will be received until further notice for position in Bureau of Standards at $1,200 to $1,380 a year.

Technologist.—Positions of associate technologist, $2,000 to $2,800 a year, and assistant technologist, $1,400 to $1,800 a year, in the Bureau of Standards will be filled from this examination. Applications will be received until further notice. Applicants must qualify in rubber, leather, paper, textile, oil or general technology.

In all the positions mentioned, appointees at annual compensation of $2,500 or less, whose services are satisfactory, may be allowed the temporary increase of $20 per month granted by Congress.

Dr. Whitney to Receive Chandler Medal

At a meeting to be held in Havemeyer Hall, Columbia University, at 8:15 p.m. on April 27, the Chandler medal will be presented to Willis Rodney Whitney, director of the research laboratory of the General Electric Co. Dr. Whitney will speak on "The Littlest Things of Chemistry."

The Charles Frederick Chandler Foundation was established in 1910 by friends of Prof. Chandler. The income from this fund is used to provide a lecture by an eminent chemist and to provide a medal to be presented to the lecturer in further recognition of his achievements in science. Previous lecturers on this foundation were Dr. L. H. Baekeland and Dr. W. F. Hillebrand.

Navy Releases Sodium Nitrate for Fertilizers

To assist in relieving the shortage of fertilizing materials the Secretary of the Navy has authorized the sale of 9,925 tons of its surplus of sodium nitrate.

No Liquidation of American Property in Germany

From the first issue of *Transatlantic Trade*, the official organ of the American Association of Commerce and Trade in Berlin, we quote the following note relative to the way in which Germany handled American property during the war:

"There have been so many false reports circulated in the United States as to what happened to American property in Germany during the war that a statement of actual facts seems necessary. American commercial interests were neither liquidated nor sold. Personal and household property of our citizens underwent no change whatever; today American citizens are in full possession of their property. Former members of the American colony, now in the United States, will be glad to learn that their property is intact; much of such property was stored in warehouses at the beginning of the war in 1917. In several cases the storage rent has not been paid, but the German agencies to whom it was entrusted are still carrying this property pending claims of the rightful owner. American business houses in Germany were put under a controller at a salary in keeping with the firm's financial capacity. The principal functions of this controller were to watch the company's finances, and to exercise a general control over the undertaking. His instructions prevented him from injuring the American features of the undertaking.

"In several cases the action of the controller has given rise to criticism. Reference is made to those American firms with headquarters in Berlin and a large network of agencies scattered over the country. With importation of goods cut off, it seemed advisable to the controller, in the interests of the company, to close up these agencies in other cities which involved a large expense in office and shop rent and salaries. This act has been looked upon by the head offices in the United States as a partial liquidation, but the controller defends the act by stating that it was in the company's interests. With the head office intact, he claimed that agencies could be reopened after the war when goods were available: German firms were doing the same."

Freight Rates on Sodium Nitrate

On complaint of the General Chemical Co., the Interstate Commerce Commission has handed down an important decision reducing the rates which have been charged on sodium nitrate imported from Chile, from north Atlantic ports to points in the Middle West. The Commission prescribes rates which are to govern in the future, as follows: New York to Hegewisch (a Chicago rate point) 33c. per 100 lb.; New York to Willow, Ohio, 71 per cent of the Hegewisch rate; Philadelphia and Baltimore to Hegewisch and Willow, and from Baltimore to Ivorydale, 100, 71 and 87 per cent, respectively, of the New York-Hegewisch rate. These rates apply to carload lots and do not include the regular port differentials.

Idaho Phosphate Rock for the Orient

A recent development in the utilization of the phosphate deposits of the West is to be noted in a contract for the shipment of 35,000 tons to Japan. The rock will be mined at Paris, Idaho, and shipped via Portland, Ore. This is to be considered in the light of a preliminary shipment and it is estimated by the Portland Chamber of Commerce that about 300,000 tons of the rock will be thus exported from that port this year.

Engineering and Accident Prevention

For the purpose of bringing the safety movement and the engineering world more closely together, the Engineering Section of the National Safety Council has called a conference of all persons interested in engineering and accident prevention, to be held at the Engineering Societies Building in New York City, April 27. The morning session will first take up the relationship of safety and engineering efficiency—the question whether, apart from its human values, safe operation of a factory or a railroad is in truth inseparably connected with efficient operation. If this question can be answered in the affirmative, the answer will prove conclusively that safety is worthy of greater attention from engineers and that it deserves a place in the curriculum of engineering colleges. This topic—safety education in technical schools—is the next subject on the program. The afternoon session will be devoted to safety standards: first, the present movement for uniform standards; second, the National Safety Council's part in this movement.

Patent Royalties for Government Employees

Government employees are to receive a portion of any royalties which may accrue from patents which may be made of discoveries or inventions made or developed on Government time, according to the provisions of a bill which just has passed the Senate. The Federal Trade Commission is assigned the duty of administering the patents for the benefit of the public. The President is to fix the percentage which is to be allowed the employees.

Water-Power Bill Delayed

Meetings of the conferees on the water-power bill again are being held, but little progress is being made in adjusting the differences between the bills as passed by the Senate and by the House. Some fear protracted delay before a compromise can be agreed upon.

Book Reviews

INORGANIC CHEMICAL SYNONYMS. By *Elton R. Darling, Ph.D.*, in charge of industrial chemistry department, Newark Technical School. 100 pp. New York: D. Van Nostrand Co. Price, $1.

In the commercial world, chemical products are frequently known by names which have no apparent connection with scientific nomenclature. Furthermore, these colloquialisms vary according to geographical location, so that a single chemical may be represented by as many as twenty different terms. Most chemists will recall instances in which a great deal of time and effort was expended in search of the meaning of some strange new compound, only to find that it was an old laboratory friend masquerading under a trade name.

In this book, the author has gathered together over seven hundred synonyms for one hundred and twenty compounds of the following elements: Aluminum, antimony, arsenic, barium, bismuth, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, zinc, hydrogen. A separate section is devoted to each element in the order given, with a few introductory paragraphs giving the physical properties and a brief review of the history of the element. Under iron, as an example, we find that ferric oxide has the following synonyms: Ferri oxidum, ferri sesquioxidum, ferri rubigo, rubigo, ferri peroxidum, ferri oxidum rubrum, peroxide of iron, red oxide of iron, iron rust, sesquioxide of iron, crocus ferri, crocus martis, ferrugo, polishing crocus, jewelers' rouge, venetian red, stone red, purple oxide, scarlet red.

A miscellaneous section contains eighty additional synonyms covering compounds not included in other sections. An excellent alphabetically-arranged cross-index enables one to identify quickly names which do not indicate the true chemical nature of the compound. The value of the book for reference work is increased by the inclusion of tables giving atomic weights, dates of discovery of the elements, occurrence of the metals in nature, temperature interconversions, comparison of specific gravity and degrees Twaddell and Baumé, weights and measures and conversion factors.

A few errors will be noted, such as listing barytes as a synonym of barium oxide, but these will undoubtedly be corrected at the first opportunity. As a time-saver, the book deserves the attention of every chemist in contact with the field of industrial chemistry.

ALAN G. WIKOFF.

Personal

Dr. HENRY ARNSTEIN, formerly technical director of the Cereal Products Refining Co. of San Francisco, has recently opened offices at 573 Twenty-second Ave., San Francisco. Dr. Arnstein has specialized in the manufacture of compressed yeast, maltose, alcohol, fats, vegetable oils and other food products and will enter consulting practice along these lines.

E. M. BISSONETTE, formerly with E. I. du Pont de Nemours & Co., Deepwater, N. J., is now with the Atlantic Refining Co., Pittsburgh, Pa.

F. W. BROWN recently resigned his position as sulphite superintendent of the Cascade Mill, Berlin, N. H., to accept the position of general manager of the bleached sulphite pulp plant of the Fraser Cos., Ltd., Edmundston, N. B.

GEORGE N. FISHER, formerly associated with the Certain-teed Products Corp., Niagara Falls, is now connected with the General Chemical Co., East St. Louis, Ill., as chemist.

F. C. FREEMAN, chief engineer for the Providence Gas Co., Providence, R. I., recently gave an illustrated lecture before the Providence Engineering Society on the manufacture of gas.

JOHN S. HARRIS, formerly of Klondike, Ariz., is now employed in the chemical department of the Empire Gas & Fuel Co., El Dorado, Kan.

E. J. HORWOOD, works manager for the Broken Hill Proprietary at Broken Hill, has been transferred to the Melbourne office of the company.

Dr. EDWARD H. HUME, head of the Yale University movement in China, addressed the Chicago Foreign Trade Club last week on the organization of the China Society of America.

HENRY N. LYONS, formerly with the Hercules Power Co., is now chief chemist with the Columbia Chemical Co., Barberton, Ohio.

Prof. ELIHU THOMSON, Swampscott, Mass., chief consulting engineer, General Electric Co., Lynn, Mass., has been appointed acting head of the Massachusetts Institute of Technology until a successor is chosen for the place, which was made vacant by the death of Richard Maclaurin.

HENRY LANE WILSON, former Ambassador to Mexico, spoke before the Detroit Chamber of Commerce on March 23, on business conditions in Mexico.

H. W. YOUNG, research chemist for the gas department of the Midwest Refining Co., has returned after an extended tour of the East, collecting information to be used in equipping an experimental laboratory at Salt Creek, Wyo.

Obituary

JOHN JEPPSON, superintendent and one of the founders of the Norton Co., Worcester, Mass., died in the Plaza Hotel, Havana, Cuba, Friday night, March 26, after an illness of two weeks. Mr. Jeppson's sickness dated from an attack of acute indigestion, from which he recovered sufficiently to reassure his relatives as to his condition, and the news of his death, received by Charles L. Allen, treasurer and general manager of the Norton Co., in a dispatch from George N. Jeppson, Mr. Jeppson's son, came as a surprise and shock to his thousands of Worcester friends.

Mr. Jeppson was born on a farm near Hoganas, Sweden, July 1, 1844, the son of Godman and Bengta (Person) Jeppson, and was seventy-five years, eight months and twenty-five days old. His remarkable career in Worcester began April 29, 1869, four days after he landed in New York, a poor Swedish immigrant.

Current Market Reports

The Non-Ferrous Metal Market

New York, April 5, 1920.—The copper market is still steady. March exports totaled 13,100 tons. For May delivery the price is 19.25c. There has been no movement in the price of nickel for a number of weeks, but silver has been fluctuating and is now $1.26½, against $1.23½ last week. Lead and zinc are steady both here and in East St. Louis. Tin has advanced a cent, as have scrap metals. Mercury is up $8 over last week.

	Cents per Lb.
Copper, electrolytic	19.00
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	10.50@10.75
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	62.50
Lead, New York, spot	8.87½
Lead, E. St. Louis, spot	8.60
Zinc, spot, New York	9.00
Zinc, spot, E. St. Louis	8.60

OTHER METALS

Silver	oz.	$1.26½
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f.o.b. Niagara Falls)	lb.	1.60
Platinum	oz.	142.00
Iridium	oz.	250.00
Palladium	oz.	142.00
Mercury	75 lb.	103.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	26.75
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless bronze tubing	34.50
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	23.50@24.50
Aluminum, sheet scrap	23.50@24.50
Aluminum clippings	27.00@28.00
Copper, heavy machinery comp	16.00@16.50
Copper, heavy and wire	15.75@16.25
Copper, light and bottoms	14.50@15.00
Copper, heavy cut and crucible	16.50@17.25
Brass, heavy	10.00@10.50
Brass, casting	8.50@9.00
Brass, light	10.00@10.25
No. 1 clean brass turnings	13.75@14.25
No. 1 comp. turnings	11½@11½
Lead, tea	5½@5½
Lead, heavy	7@7¼
Zinc, scrap	4½@4½

The Iron and Steel Market

Pittsburgh, Pa., April 2, 1920.

The iron and steel market has become still quieter, and may almost be described by the term stagnant. The situation does not necessarily reflect any loss in the fundamental strength of the iron and steel position, though of course the extreme conservatism of banking interests at this time and the fear in some quarters that there will be an industrial depression in the near future might be contributing causes. The quietness in the iron and steel market is rather to be ascribed to the technical position of the market, through its having undertaken an advance which it could not sustain. The fancy prices recently paid for prompt deliveries of steel products, including not only sheets and plates but also several other descriptions of steel, are passing and indeed have already passed except for a very limited turnover. The higher prices being charged by large independents over Steel Corporation prices also have to go, though the complete elimination of these premiums may not be until quite a while in the future. With the steel market in process of readjustment buyers are naturally indisposed to take hold.

CAUSES OF STEEL MARKET DULLNESS

In the foregoing reference to the dullness in the steel market reference was made to two causes as if they were totally separate and distinct, but that, perhaps, is not the case. Reference was made to the general industrial and financial situation, on the one hand, and to the technical position of the steel market itself on the other. In a sense, however, the latter is a replica on a small scale of the former. The financiers and others who hold that there must be a readjustment in values and credits, and that there may be a mild industrial depression as a process of readjustment, maintain that prices are too high, that there is such inflation that sound business on a large scale cannot be conducted. If that is the general or average situation in business, the steel situation is the same thing in its narrower sphere. Steel prices started to advance above the Industrial Board price schedule of March, 1919, except that the United States Steel Corporation elected to continue selling at those prices. Many independent steel producers predicted a "runaway market" in steel, and the runaway actually started. Perhaps the proximate cause of the arrest of the runaway market was a production larger than had been expected by those who, actuated by their fears of a steel famine, paid fancy prices for prompt deliveries to eke out their contract deliveries, but a runaway would have been prevented from going far, even with smaller production, by a large amount of latent demand being held back from actual expression. Neither the railroads nor investment buyers generally would invest in steel at prices obviously affording the producers an inordinate profit after paying very high wages and buying supplies at extremely high levels.

Thus the steel market requires a readjustment because it had started out on the road of inflation, but what the bankers assert is that the whole country is on an inflated basis and all commercial operations will have to be adjusted to a more moderate, and therefore safer, level. Accordingly, whether one attributes the present dullness in the steel market to there having begun a readjustment in business generally, or to there having begun a readjustment in steel prices, in either case the matter rests upon the same economic principle, that successful business cannot long be conducted on an inflated basis. It is pertinent to observe another connection, that the Steel Corporation has steadfastly refused to participate in the advance in steel prices, adhering to the Industrial Board schedule, and that the policies of the Steel Corporation are, in the last analysis, directed largely by financial interests.

RAILROAD BUYING

When inquiries for freight cars began to appear in volume at the beginning of March, when the railroad lines were returned to their owners, it was predicted that car buying on this movement would involve not less than 50,000 cars and might run to 100,000 cars. Now it appears doubtful

whether even the lower figure will be attained. The chief difficulty mentioned is that of financing, the railroads offering payment largely in notes, and in some cases proposing to pay only 25 per cent in cash. Undoubtedly another difficulty is that the railroads feel that prices are too high, since the car companies could secure but little steel for early deliveries at the Steel Corporation prices. There is scarcely any railroad inquiry for bridges and structural material generally.

Steel Prices and Sales

The large independent steel companies have not formally opened their order books for third quarter deliveries of such materials as bars, shapes and plates, but may do so shortly. It appears that their customers prefer that the opening should occur later, preferring not to be forced to commit themselves just at this time. Some business has been done, however. Mills have been stating that they do not expect to set their third quarter prices at above 3c. for bars, 3.10c. for shapes and 3.25c. for plates. The Steel Corporation continues to sell in most of its lines, but transactions have been lighter of late, and the corporation's unfilled tonnage statement may show a decrease for March, after heavy increases in preceding months.

Open Coke Market

In one branch of the general market there have been spectacular performances in the past week, the Connellsville coke market. Predictions have been made that when Government price limits, $6 for furnace coke and $7 for foundry, should be removed the market would advance to $9 or thereabout for furnace coke. The actual removal of the restrictions became actually effective at the end of March, but before that time transactions began, for shipment and invoicing April 1 and later. The initial sales were at $9, a few prompt lots going at this figure as well as a fair sized tonnage for the month of April and a small monthly tonnage for the remainder of the year. Then the market began advancing sharply from this level, by 50c or $1 a day, and in the past two or three days it has stood at $11 to $12 for furnace and at $13 to $14 for foundry coke per net ton at ovens. Coke operators seemed to feel that the price should be the same whatever the delivery, whether April, second quarter or balance of year, but at such high levels furnaces became reluctant to commit themselves for more than the month of April.

Nearly all the April business has now been done. The turnover has been chiefly in coke that was released by the expiration of first quarter contracts or understandings between producer and consumer, good for the period of Government control, that coke would be furnished and invoiced at the Government price. As contract deliveries had been somewhat under requirements, the termination of these contracts and understandings operated to create larger uncovered consumption than unsold production.

The advance in coke seems to have had a stiffening effect upon the attitude of blast furnaces in the matter of pig-iron prices, which are now quite firmly held. Pig-iron consumers, however, are not in the market to any extent.

Chemical and Allied Industrial Markets

New York, April 5, 1920.

There has been no change in the general condition of the heavy chemical market during the past week. Spot offerings are practically unobtainable and there is very little material to be had on future delivery. Prices have strengthened and where there has been no actual rise quotations are firmer at the previous levels. The shipment of supplies from the West is still being hampered by transportation difficulties.

General Chemicals

Barium chloride still remains in a nominal position. Spot material is practically unobtainable and producers are working to fill back contracts. The quotation of $140@$150 per ton still holds. *Potassium bichromate* is firmer at 36@37c. per lb. than at the previous quotation of 32@33c. There is very little material available and producers are reported well sold up for the next few months. *Chloroform* came up slightly, being listed at 29@30c., against 28c. of last week. The usual business is being done, with nothing of particular interest in view. *Alcohol*, wood, has jumped still higher, quotations ranging from $2.35@$3.50 per gal. according to the proof. *Caustic potash* is practically unobtainable, the present listing being 28@29c. per lb. Supplies on *sal soda* are still tighter, which has affected the price, it being listed at $22@$26 per ton, against $21@$22 of last week.

Coal-Tar Products

The already reported shortage in all branches in this market still holds. Crude material is especially short and this is holding up production to such an extent that the spot market is at a standstill. There is no scarcity of buyers who are anxious to obtain material at most any price. *Aniline oil* has tightened up slightly, being listed at 34@45c. per lb. *Dimethylaniline* is still off the market, although some small quantities have changed hands at $1.50 per lb.

Naval Stores

This market remains in the same position in which it was last week. Rosins are still scarce, while turpentine is not to be had in the New York market at any price, but $2.36 per gal. is the nominal quotation of the week.

Crude Rubber

This market has been at a standstill during the past few weeks. There are several reasons for this condition, the principal one being fluctuating foreign exchange, as manufacturers will not go in the market on a speculation basis. Other contributing causes are the present condition of the spot market in relation to future delivery and the difficulty on the part of the tire manufacturers to obtain fabric, which has limited the buying of rubber. During the war the Government cut importations of crude rubber in half, which allowed large quantities to accumulate, and this material is now being offered on the spot market, causing future offerings to be turned down by the buyer for the more favorable spot price. The extreme tire fabric shortage is also a large factor in the present depression, as manufacturers will not buy the rubber when their output is being limited by the small quantity of fabric being received. It is the opinion of those doing business in this market that a firm rising exchange will go a long way toward putting this market back in its former position.

Ferro-Alloys

Ferromanganese continues upward with no relief in sight. Car shortage and labor trouble at the docks, combined with the extreme shortage of supplies are accountable for the increasing market price on this item. Quotations on English material for prompt shipment are $200 per ton and for last half $175@$200 is being asked, with no actual offers to be found even at these prices. Domestic is listed $235@$240 prompt delivery and $200@$220 for last half.

Spiegeleisen remains firm, with business being transacted at prices ranging from $60@$65 per ton.

Miscellaneous

The barytes market is at a standstill, as there is very little material to be obtained. Demand so far exceeds output that producers have warned their selling representatives not to take any more contracts without first consulting the works. No price is being quoted on contract goods, all goods being sold at current price at time of delivery. The spot market is also practically bare of this material and as high as $40 per ton is being asked for white floated, while the off-color grade is listed at $25@$30 per ton.

Tungsten is firmer under the influence of pending legislation. Although there has not been any larger business than usual, *wolframite* is firmer at $6.50@$7.50 per unit than it was last week.

Fullers earth remains firm at $25@$30 for domestic and $35@$40 for foreign, with very little material available at these prices.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.60 – $0.65
Acetone	lb.	$0.13 – $0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.25 – 3.50
Acetic, 56 per cent	cwt.	6.00 – 6.50	7.00 – 7.50
Acetic, glacial, 99½ per cent. carboy	cwt.	12.00 – 14.00	15.00 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Citric	lb.	.85 – .86	1.19 – 1.25
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 – ....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P	lb.	—	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07½	.08 – .09¼
Oxalic, crystals	lb.	.35 – .42	.43 – .48
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	.... – ....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	.... – ....
Sulphuric, 60 deg., drums	ton	.... –	.... – ....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	.... – ....
Sulphuric, 66 deg., drums	ton	.... –	.... – ....
Sulphuric, 66 deg., carboys	ton	.... –	.... – ....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 – ....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 – ....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – ....
Tannic, U. S. P	lb.	—	1.35 – 1.45
Tannic (tech.)	lb.	—	.60 – .80
Tartaric, crystals	lb.	—	.69 – .74
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.35 – 3.50	—
Alcohol, denatured, 188 proof (nominal)	gal.	—	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	—	.98 – 1.02
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .05½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ – .10½	.11 – .12
Ammonia, anhydrous, cylinders (100-156 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.15 – .15½	.16 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	.... – ....
Ammonium sulphate	lb.	.05 –	.06 – ....
Amylacetate	gal.	—	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	—	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	—
Barium chloride (nominal)	ton	125.00 – 135.00	140.00 – 150.00
Barium dioxide (peroxide)	lb.	.23 – .27	.28 – .30
Barium nitrate	lb.	.17 – .19	.20 – .22
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)	....	—	.... – ....
Blue vitriol (see copper sulphate)	....	—	.... – ....
Borax (see sodium borate)	....	—	.... – ....
Brimstone (see sulphur, roll)	....	—	.... – ....
Bromine	lb.	.85 – .90	.... – ....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – ....
Calcium carbide	lb.	—	.04½ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite(bleaching powder)	cwt.	—	4.00 – 4.50
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)	....	—	.... – ....
Caustic soda (see sodium hydroxide)	....	—	.... – ....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.29 – .30	.31 – .32
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)	....	—	.... – ....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08½ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)	....	—	.... – ....
Epsom salt (see magnesium sulphate)	....	—	.... – ....
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)	....	—	.... – ....
Glycerine	lb.	—	.24½ – .26
Iodine, resublimed	lb.	—	4.10 – 4.30
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.50 – 2.00
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	—	.13 – .17
Lead nitrate, crystals	lb.	—	.70 – .90
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	—	1.50 – ....
Magnesium carbonate, technical	lb.	—	.13 – .14½
Magnesium sulphate, U. S. P	100 lb.	3.40 – 3.55	3.60 – 3.75
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –	.15 – ....
Nickel salt, single	lb.	.16 – .17	.17½ – ....
Phosgene (see carbonyl chloride)	....	—	.... – ....
Phosphorus, red	lb.	—	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.36 – .37	.38 – .40
Potassium bitartrate (cream of Tartar)	lb.	—	.56 – .60
Potassium bromide, granular	lb.	—	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.15 – .20	.21 – ....
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .35
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – ....
Potassium permanganate	lb.	—	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.2[illegible]
Potassium prussiate, yellow	lb.	.34 – .36	.38 – .40
Potassium sulphate	ton	$225.00 –	.... – ....
Rochelle salts (see sodium potas. tartrate)	....	—	.... – ....
Salammoniac (see ammonium chloride)	....	—	.... – ....
Sal soda (see sodium carbonate)	....	—	.... – ....
Salt cake	ton	22.00 – 26.00	.... – ....
Silver cyanide (nominal)	oz.	—	1.25 – ....
Silver nitrate (nominal)	oz.	—	.77 – 82½
Soda ash, light	100 lb.	—	3.50 – 3.60
Soda ash, dense	100 lb.	2.70 – 2.75	3.55 – 3.65
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.05½ – .06½	.07 – .07½
Sodium borate (borax)	lb.	.08½ – .08¾	.09 – .09½
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	—	6.75 – 7.00
Sodium hyposulphite	lb.	—	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25 – ....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	—	.25 – .30
Sodium peroxide, powdered	lb.	—	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .2[illegible]	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .0[illegible]
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.40	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (cone)	lb.	—	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – ....
Sulphur chloride	lb.	.05½ –	.06 – ....
Sulphur, crude	ton	22.00 –	.... – ....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – ....
Zinc carbonate, precipitate	lb.	—	.19 – .20
Zinc chloride, gran.	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.11¼ – .12½	.13 – .15
Zinc oxide, U. S. P	lb.	—	.19 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.42 —	.48
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.35
Benzidine, sulphate	lb.	1.00 —	1.15
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.65
Beta naphthol, sublimed	lb.	.70 —	.90
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.70
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline (nominal)	lb.	.95 —	1.50
Dinitrobenzol	lb.	.26 —	.37
Dinitro-clorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.55 —	.65
H-acid (nominal)	lb.	1.75 —	1.90
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.08 —	.09
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.70 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.75 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.12 —	.18
Paranitraniline	lb.	1.00 —	1.35
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.15 —	3.00
Paratoluidine	lb.	1.75 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45 —	.50
Salicylic acid, U. S. P.	lb.	.55 —	.60
Salol	lb.	.90 —	1.00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.25 —	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.39 —	$0.40
Beeswax, refined, light	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1, (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.60 —	.70
Carnauba, No. 3, North Country (nominal) †	lb.	.43 —	.45
Japan	lb.	.17 —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.11
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11½
Paraffine waxes, refined, 133-135 m.p.	lb.	.12 —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.13½ —	.14
Stearic acid, single pressed	lb.	.26 —	.27
Stearic acid, double pressed	lb.	.32 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.47
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.9
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.25 —	$17.50
Rosin E-I	280 lb.	19.75 —	20.00
Rosin K-N	280 lb.	20.75 —	20.50
Rosin W. G.-W. W.	280 lb.	22.00 —	22.50
Wood rosin, bbl.	280 lb.	15.50 —	17.50
Spirits of turpentine	gal.	—	2.35
Wood turpentine, steam dist.	gal.	—	2.25
Wood turpentine, dest. dist.	gal.	—	2.10
Pine tar pitch, bbl.	200 lb.	8.40 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	15.00
Retort tar, bbl.	500 lb.	15.00 —	15.50
Rosin oil, first run	gal.	.92 —	.95
Rosin oil, second run	gal.	.94 —	.97
Rosin oil, third run	gal.	1.10 —	1.15
Rosin oil, fourth run	gal.	1.17 —	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½ —	$0.42
Upriver coarse	lb.	.30½ —	.32
Upriver caucho ball	lb.	.32½ —	.33
Plantation—First latex crepe	lb.	.47½ —	.48½
Ribbed smoked sheets	lb.	.47 —	.48
Brown crepe, thin, clean	lb.	.45 —	.....
Amber crepe No. 1	lb.	.46 —	.47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.24½ —	.25½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.19 —	.19½
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½ —	.23
Corn oil, crude, in bbls.	lb.	.17½ —	.19
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.18
Cottonseed oil, summer yellow	lb.	.19½ —	.20½
Cottonseed oil, winter yellow	lb.	.22 —	.24½
Linseed oil, raw, car lots	gal.	1.74 —	.....
Linseed oil, raw, tank cars	gal.	1.67 —	.....
Linseed oil, boiled, car lots	gal.	1.77 —	.....
Olive oil, commercial	gal	2.50 —	3.00
Palm, Lagos	lb.	.16 —	.16½
Palm, bright red	lb.	.15½ —	.17½
Palm, Niger	lb.	.15 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.20½ —	.22
Peanut oil, refined, in bbls.	lb.	.27 —	.28
Rapeseed oil, refined in bbls.	gal.	1.70 —	1.78
Rapeseed oil, blown, in bbls.	gal.	1.80 —	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16½ —	.20

FISH

Winter pressed Menhaden	gal.	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal.	1.23 —	1.24
Blown Menhaden	gal.	1.30 —	1.35

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	..... —	$40.00
Barytes, off color	ton	$20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	..... —	.....
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal)	ton	13.50 —	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	52.00 —	57.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.08
Graphite, crucible, 88% carbon content	lb.	..... —	.09
Graphite, crucible, 89% carbon content	lb.	..... —	.09½
Graphite, crucible, 90% carbon content	lb.	..... —	.10
Graphite, crucible, 91% carbon content	lb.	..... —	.10½
Graphite, crucible, 92% carbon content	lb.	..... —	.11
Graphite, crucible, plus 92%	lb.	..... —	.12½
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	.....
Shellac, orange, fine nominal	lb.	1.45 —	.....
Shellac, orange, superfine	lb.	1.60 —	1.65
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	60.00 —	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	85-95 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn	gross ton	180.00 —	240.00
Spiegeleisen, 16-20% Mn	gross ton	60.00 —	65.00
Ferro-molybdenum, per lb. of Mo	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	65.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	6.50 —	7.50

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	.....
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	.....
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00 —	30.00
Manganese ore, 45% Mn and over	unit	75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	7.50
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

LOS ANGELES—King W. Vidor has awarded the contract for the construction of seven 1- and 2-story picture-producing buildings on Santa Monica Blvd., to the Milwaukee Bldg. Co., 316 Wright & Callender Bldg. Estimated cost, $100,000.

Connecticut

MIDDLETOWN—The Standard Oil Co., 26 B'way, New York City, plans to build an oil plant along the Connecticut River. Estimated cost, $100,000.

Illinois

CHICAGO—Shea, Smith & Co., 322 Federal St., manufacturing stationers, plan to build a 5-story steel and concrete factory at Congress St. and Ashland Blvd. Estimated cost, $600,000.

CHICAGO—The Vulcan Louisville Smelting Co., 208 South La Salle St., plans to rebuild a part of the North Chicago plant which was recently destroyed by fire. Estimated cost, $400,000.

Indiana

EVANSVILLE—Clifford Shopbell, 707 Furniture Bldg., will receive bids for the construction of a 2-story, 80 x 150-ft. factory for the Liquid Carbonic Co., Heidelback Ave. and Indiana St. Estimated cost, $30,000. Noted March 3.

Kansas

PROTECTION—The city is receiving bids for the construction of a disposal plant. Filter equipment will be installed in same. Estimated cost, $50,000. W. B. Rollins & Co., 209 Railway Exch. Bldg., Kansas City, Mo., engr.

Louisiana

NEW IBERIA—The United Fiber & Products Co. has purchased the mill of the Sugar Cane By-Products Co. and will install new machinery in same. The mill will have a daily capacity of 15 tons newsprint paper. W. T. Larkin, 1520 Fidelity Bldg., Baltimore, Md., pres. F. Logan, 467 C St., N. W., Washington, D. C., engr.

Maryland

BALTIMORE—The Presto-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of eight 1-story, 25 x 100-ft. acetylene plants. Estimated cost, $75,000.

LANSDOWNE—The Natl. Steel Rolling Co., 203 Keyser Bldg., Baltimore, has purchased the plant of the Schuylkill Haven Rolling Mill Co., Schuylkill Haven, Pa., and plans to build a subsidiary plant near here. The plant will be an oil and electric steel reclaiming bar mill and will have an annual capacity of 9,000 tons. Estimated cost, $100,000.

Massachusetts

FITCHBURG—Croker, Burbank & Co., 549 Westminister St., has awarded the contract for the construction of a 2-story, 46x300-ft. machine shop, 1-story, 54x100-ft. spinning shop and a 2-story, 130x130-ft. beader shop, to E. J. Cross Co., 82 Foster St., Worcester. Estimated cost $400,000.

Michigan

NORTHVILLE — The Detroit Bd. of Health, 233 St. Antoine St., Detroit, received bids for the construction of a 2-story, 28x36-ft. laboratory, in connection with the group of buildings to be constructed at the proposed Detroit Municipal Tuberculosis Sanitarium, from John Finn & Co., 234 East Fort St., Detroit, $29,375; George A. Fuller Co., 540 Penobscot Bldg., Detroit, $30,700. Noted Feb. 26.

Missouri

ST. LOUIS—The Amer. Bakers' Machine Co., 2121 North 9th St., plans to build a factory and office building on Kingshighway and McRee Ave. Estimated cost, $110,000.

ST. LOUIS—The Skinner Bros. Mfg. Co., 10th and Tyler Sts., builders of industrial heaters and blow piping systems, is building a factory at Lunt and Vandeventer Ave. Estimated cost, $250,000.

New Jersey

NEWARK—The Seaboard Chemical Co., Blanchard St., has awarded the contract for the construction of a wood alcohol plant, to Edward M. Waldron, Inc., 665 Broad St. Estimated cost, $40,000. The company will be in the market for chemicals for the manufacture of wood alcohol.

PLEASANTVILLE—The Common Council, City Hall, will receive bids until April 19 for the construction of a sewage screening plant, etc.

TRENTON—The Kelso Mfg. Co., asbestos manufacturer, 58 Market St., plans to construct a factory addition on Market St.

New York

BROOKLYN—Fred A. Phelps, archt., Union Bldg., Newark, N. J., will receive bids until April 24 for the construction of a 4-story, 55x175-ft. paint factory at Hamilton and Smith Sts., for Devoe Reynolds, 460 Smith St., and will be in the market for chemicals for the manufacture of paint. Noted March 17.

BUFFALO—The Hewitt Rubber Co., Kensington Ave., plans to build a 2-story brick addition to present plant. Estimated cost, $25,000.

New Mexico

LORDSBURG—The Great Eagle Mine is in the market for crushing machinery, etc. J. W. Cauthen, supt.

Ohio

ASHLAND—The city has awarded the contract for the furnishing and installing of filter equipment for the proposed 1-story filtration plant, to the Amer. Water Softener Co., 1011 Chestnut St., Philadelphia, Pa., at $34,000. Noted March 31.

CINCINNATI—The Presto-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of a few 1-story, 25 x 100-ft. acetylene plants. Estimated cost, $75,000.

CLEVELAND—The Cleveland Steel Co., Rockefeller Bld., plans to build a 1-story steel plant on West 117th St. and the Big Four R.R. Estimated cost, $350,000. C. J. Jones, mgr. A. S. McKee Co., Rockefeller Bldg., engr.

ELYRIA — H. A. Beck, Dir. of Pub. Servc., City Hall, will receive bids until April 26 for the furnishing and installing filter plant equipment.

DOVER—The Dover Mfg. Co., c/o Poe Eng. Co., archt. and engr., Rockefeller Bldg., Cleveland, O., plans to build a 3-story, 80x200-ft. factory. Estimated cost, $100,000.

Pennsylvania

PHILADELPHIA—The Presto-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of a few 1-story, 25x100 ft. acetylene plants. Estimated cost, $80,000.

South Dakota

MOBRIDGE—The city had plans prepared for the improvement of the waterworks system, taking water supply from the Missouri River, with filtration. Estimated cost, $175,000.

Texas

TEMPLE—The Southland Oil Co. is rebuilding its cotton seed-crushing plant. E. A. Dill, engr. Estimated cost, $60,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive at St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHAMBER OF COMMERCE OF THE U. S. announces that its eighth annual meeting will be held at Atlantic City, April 27 to 29, the subject of which will be "Increased Production."

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Romance of Leather Making," Tuesday, April 13, at 4 p.m., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 p.m., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE ELECTRIC FURNACE ASSOCIATION will hold a meeting in Boston, April 8 to 10, together with the American Institute of Electrical Engineers and the American Electrochemical Society. The subject is "Electrically Produced Alloys and Power for Electrochemical Purposes." Headquarters will be at the Copley-Plaza Hotel.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INTERNATIONAL MINING CONVENTION will be held in Seattle April 7 to 10.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NATIONAL SAFETY COUNCIL, Engineering Section, will hold its spring conference in the Engineering Societies Building, New York City, on April 27.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.